Wellingtonia gigantea.

THE

VEGÉTABLE WORLD;

BEING

A HISTORY OF PLANTS,

WITH THEIR BOTANICAL DESCRIPTIONS AND PECULIAR PROPERTIES.

BY LOUIS FIGUIER,

AUTHOR OF "THE WORLD BEFORE THE DELUGE," AND OTHER POPULAR WORKS.

ILLUSTRATED WITH 446 ENGRAVINGS, INTERSPERSED THROUGH THE TEXT, AND 24 FULL-PAGE ILLUSTRATIONS;

CHIEFLY DRAWN FROM NATURE

BY M. FAGUET,

ILLUSTRATOR TO THE BOTANICAL COURSE OF THE FACULTY OF SCIENCES OF PARIS.

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PREFACE.

The present Volume may be considered as the second contribution which M. Figuier has made towards his *Tableau de la Nature*. "The World before the Deluge" contemplates a period in the earth's history when its natural ornament was absent; when its surface was an arid desert—a vast solitude—the abode of silence and death. Plants preceded animals in the order of creation; when the great animals which preceded man were created by the wisdom of the Eternal, the earth was already clothed in a mantle of vegetation. We learn from Holy Scripture that "God said, Let the earth bring forth grass, the herb yielding seed, and the fruit-tree yielding fruit after his kind, whose seed is in itself, upon the earth: and it was so. And the earth brought forth grass, and herb yielding seed after his kind, and the tree yielding fruit, whose seed was in itself, after his kind: and God saw that it was good." (Genesis i. 11, 12.)

Yes, it was good; for plants are at once the ornaments of the earth and the means of existence to the beings which occupy it; and this natural ornament the infinite goodness of the Creator has diversified in a wonderful manner, so that no part of the globe can be said to be deprived of it; and, as a natural consequence, plants have been the theme of great writers in all ages. Homer has sung their praise; Hesiod, Theocritus, Lucretius, Virgil, Horace, Ovid, and Claudius, among the Latins, have described them; and poets of all countries have been inspired by them. Infancy loves flowers,

they are charming to the young, and in more advanced years we salute them for the remembrances they awaken—perhaps for graver reasons, for who can watch the annual return of the leaves and flowers and green herbage of spring without wonder and astonishment? Vegetation, considered in connection with the rest of animated creation, leads to the consideration of GOD the Creator. In contemplating the marvellous arrangements which rule the movements of life, in admiring the multiplied organs by means of which the vegetating functions are accomplished, the thoughtful mind necessarily rises from Nature to its Creator.

The History of Plants which is now submitted to the reader is divided into four parts:—

I. The Organography and Physiology of Plants, comprehending under these heads the description of the essential organs which enter into the composition of vegetables, and some explanations of the various functions performed by means of these organs.

II. The Classification of Plants,—namely, the principles upon which the distribution of plants into particular groups rests; and along with this, brief sketches of the lives of the more eminent Botanists who have devoted themselves to this branch of the study of Plants.

III. The Natural Families of Plants. In this section the Editor has departed from the original, being desirous of giving as complete a view of the Vegetable World as his limited space would permit, and according to the system of classification most received where the English language is spoken. While departing from his arrangement, however, the subjects which the Author had selected for more special illustration have been preserved. His idea was to make a selection of the more important families, describe a plant which was taken as a type of the order, and notice the most prominent species belonging to the group, with their properties; this idea has been adopted and considerably enlarged upon.

IV. Geographical Distribution of Plants on the surface of the globe—a frame-work which embraces the entire circle of studies which constitute the science of Botany.

With respect to the illustrations, we may mention that they are nearly all drawn from nature. Those which are connected with Cryptogams or Thallogens are borrowed from the original memoirs, which have appeared in the "*Annals des Sciences Naturalle.*" M. Faguet has in these designs happily united the sentiment of the artist with the precision of the naturalist.

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descend through the holes in the box into the dry air, in which they will soon be dried up. It is not moisture therefore that roots seek after.

It has been suggested that the action of gravitation would take

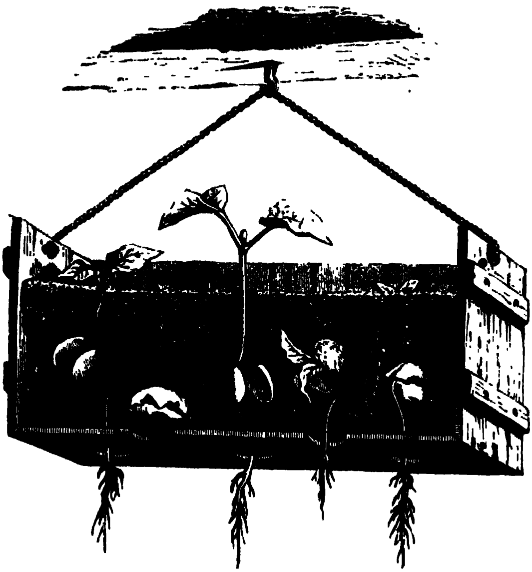

Fig. 17.—Box experiment.

some part in the guidance of the roots. This is, in fact, the apparent tendency of the following experiments.

Beans have been made to germinate when placed on the circumference of an iron or wooden wheel surrounded with moss, so as to maintain the moisture of the seeds, and holding little troughs full of mould, open on two sides (Fig. 18); the wheel being put in motion in a vertical direction by a current of water and made to describe many revolutions in a minute. In consequence of this rotary movement, producing the particular force known in mechanics as *centrifugal force*, the action of gravitation being as it were annihilated, and the sprouting seed removed from its influence, and subjected to *centrifugal force* only; now see what occurs. The small rootlets, which in ordinary circumstances would be directed upwards, that is to say, in a direction inverse to the action of gravitation,

which roots have to avoid it. In a room lighted by a single window, place a few germinating mustard seeds on a piece of cotton, and let it float on water in a vessel. It will soon be seen that the small roots point towards the dark part of the room, while the stalklets bend over to meet the rays of light coming from the window.

What can be the cause which determines this natural and invincible tendency of roots towards the interior of the earth? Is it that they would avoid the light because its action might be injurious to them? Do they seek for moisture? The two following experiments will assist the reader to answer these questions.

Place a few seeds upon a wet sponge contained in a glass tube, and light the apparatus from below. When the plant shall have germinated, and pushed out roots and rootlets, they will appear as represented in Fig. 16; the small fibres descend towards the lower part of the tube, and consequently towards the light, in obedience to their natural tendency. Therefore roots do not bury themselves in the ground to avoid the light, for in this experiment it is precisely towards the light that they take their course.

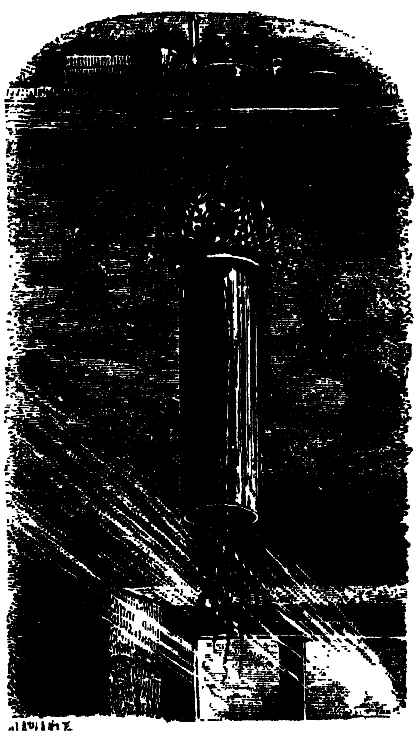

Fig. 16.—Tube experiment.

Take a box whose bottom is pierced with holes, as represented in Fig. 17, and fill it with mould; place a few kidney beans in these holes, and suspend the apparatus in the open air. The roots will not ascend in order to seek the humid earth. Obedient to the inflexible law which guides them, they will be found to

ating their spurs into the bark of trees or on the surface of a wall, they support the plant, but without nourishing it.*

There is one family of plants, the *Cuscutaceæ*, which are, above all others, parasitic. They will grow on almost any plant they can lay hold of, producing in the autumn abundance of sweet-scented flowers, but the plants to which they have attached themselves find their sap resistlessly drawn from them. The Dodder (*Cuscuta Europæa*), Fig. 15, is an example where the suckers form true nourishing roots.

Fig. 15.—Suckers of the Dodder plant.

The fundamental property of roots in a physiological point of view, is their constant endeavour to bury themselves in the earth. They seem to shun the light of day, and this tendency is to be remarked from the very first moment of the root showing itself in the germinating seed. It is a tendency so decided and appears so inherent in the life of all vegetables, that if we try to go contrary to it—if, for example, we reverse a germinating seed, placing it with the root upwards—the root and the stem will twist round of themselves; the stem will stretch upwards, and the root will bury itself in the ground.

We can convince ourselves, by a very simple experiment, of the natural inclination which stems have to seek the light of day, and

* This assertion may be doubted: it is no unusual thing to plant ivy on a damp wall, and the invariable result is to dry up the moisture. Who has not seen, with regret, some noble ash-tree covered with ivy, in whose embrace it is rapidly yielding up its life? Surely in those instances each adventitious root is draining the stem or wall to which it is attached of its sap, and transferring it to its own veins.—Ed.

form around the parent stem thousands of columns, which extend their ramifications, each throwing out new lateral branches and new adventitious roots. The natives love to build their temples in the intervals left between these roots of the wild fig, which, when they penetrate the soil, resume the functions of true roots. The famous Banyan-tree on the Nerbuddah is said, by the late Professor Forbes, to have 300 large and 3,000 smaller roots—aerial roots, as they are sometimes called. It is capable of sheltering 3,000 men, and thus forms one of the marvels of the vegetable world. It is, in short, a forest within a forest. (Plate I.) This is the celebrated Banyan-tree whose seeds are said to be so cooling and alterative.

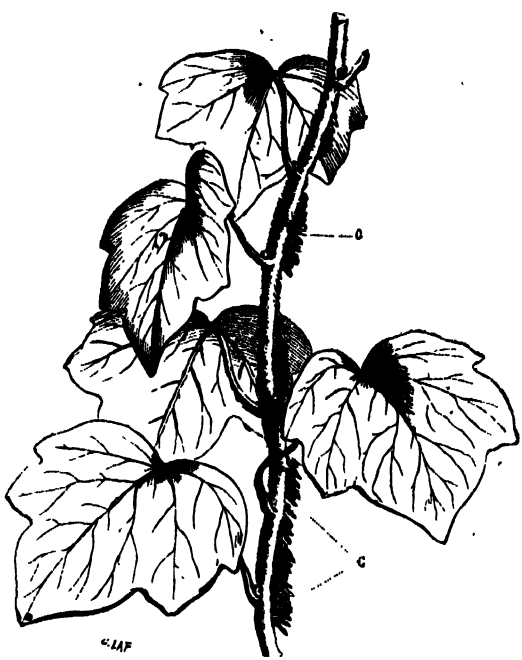

Fig. 14.—Ventitious roots of the Ivy.

The stem of the Ivy (*Hedera helix*) is furnished with root-like processes or suckers, which seem to have no other function than that of mechanically supporting the plant (Fig. 14). By insinu-

Plate I.—Pagoda Fig of India (*Ficus* [redacted]).

out adventitious roots, which descend perpendicularly in long

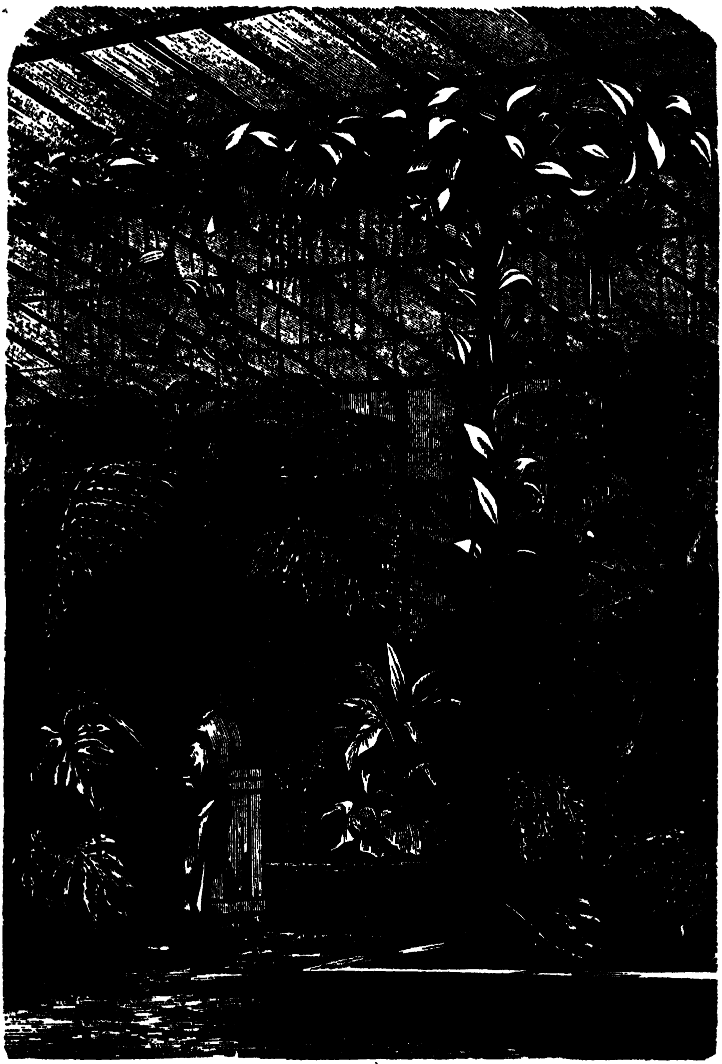

Fig. 13.—Conservatory of the Jardin des Plantes, Paris, with the climbing roots of the Vanilla.

slender shoots till they reach the ground. When they have rooted themselves in the soil, they increase rapidly in diameter, and soon

fruit is so sought after for its sweet aroma, twines its slender stem round the neighbouring trees, forming an elegant, flexible, and

Fig. 12.—Adventitious roots of the Primrose.

aerial garland, at once a grateful and pleasing ornament in these vast solitudes. The underground roots of the vanilla would not be sufficient for the nutriment of the plant, and the rising of the nourishing sap would take place too slowly. But nature has provided for this inconvenience by the adventitious roots which the plant throws out at intervals along its stem. Living in the warm and humid atmosphere of tropical forests, the stronger shoots soon reach the ground, and root themselves in the soil. Others float freely in the atmosphere, inhaling the humidity and conveying it to the parent stem. All these processes may be observed in full operation in many well-ordered conservatories.

A grand tree, the Pagoda Fig-tree (*Ficus religiosa*), adorns the landscape of India, and presents the most remarkable development of adventitious roots. When the parent stem has attained the height of some fifty or sixty feet, it throws out its lateral branches in every direction, and each branch in its turn throws

Hitherto we have occupied ourselves in considering the roots constituting the descending and normal system of vegetation. There are, however, some roots which are developed along the stem itself. Organs, supplementary in some sort, they come as helps to the roots properly so called, and replace them when by any cause they have been destroyed. In the Wheat-plant, the Dog's-grass (Fig. 11), and in general in all plants of the grass family, the lower part of the stem gives rise to supplementary roots, to which these common field plants owe a portion of their vigour and their resistance to the causes which would destroy them (Fig. 11).


Fig. 11.—Adventitious roots of the Couch-grass, *Agropyrum repens.*

In the Primrose (*Primula*) both the principal and the secondary roots which spring from it perish after some years of growth. But the *adventitious* roots (Fig. 12) springing from the lower part of the stalk prevent the plant from dying.

In the tropical forests of America and Asia, the Vanilla, whose

is not difficult to understand. In the bosom of the earth they meet with obstacles which leaves and branches never meet with in the air. The latter consequently spread freely in every direction, whilst roots are incessantly stopped by all sorts of obstacles. They are constantly cramped in their lengthening or thickening, and are forced to turn aside from the course which they ought naturally to follow, and obliged to twist round to surmount the impediments opposed to them by the unequal hardness of the soil, the presence of walls, rocks, or of other roots. From these causes arise the deformities which we notice in their outward structure, and the numerous windings observable in their branches.

The manner in which roots succeed in overcoming obstacles has always been a subject of surprise to the observer. The roots of trees and shrubs, when cramped or hindered in their progress, have been observed to exhibit considerable mechanical force, throwing down walls or splitting rocks; and in other cases clinging together in bunches, or spreading out their fibres over a prodigious space, in order to follow the course of a rivulet with its friendly moisture. Who has not seen with admiration how roots will adapt themselves to the special circumstances of the soil, dividing their filaments in a soil fit for them almost to infinity, elsewhere abandoning a sterile soil to seek one farther off, which is favourable to them; and as the ground was more or less hard, wet or dry, heavy or light, sandy or stony, varying their shapes accordingly? We are compelled to acknowledge that there is in these selections made by roots a true manifestation of vital instinct.

Duhamel, a botanist of the last century, relates, that, wishing to preserve a field of rich soil from the roots of a row of elms which would soon have exhausted it, he had a ditch dug between the field and the trees, in order to cut the roots off from it. But he saw, with surprise, that those roots which had not been severed in the operation had made their way down the slope so as to avoid meeting the light, had passed under the ditch, and were again spreading themselves over the field. It was in reference to an occurrence of this kind that Bonnet, the Swiss naturalist, said that it was sometimes difficult to distinguish "a cat from a rose tree;" a quaint, if not a witty remark.

of *fécula*, whose purpose is to aid in the development of the plant during a certain period of its existence.

Plants derive their principal nourishment from their roots. We should then naturally be led to think that the bulk of the

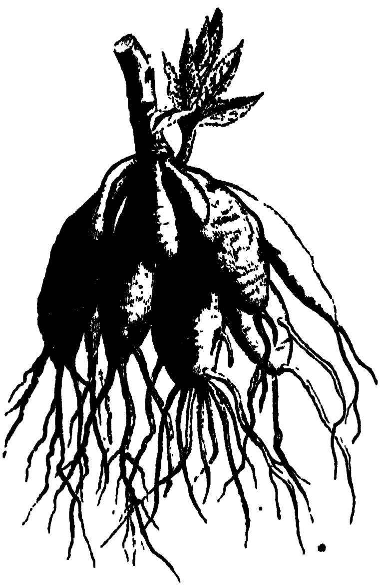

Fig. 9.—Tuberous root of the Dahlia.

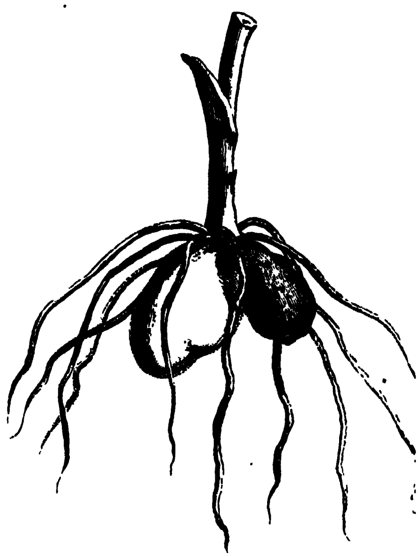

Fig. 10.—Tubero-fibrous root of Orchis masculata.

roots would be always in proportion to the size of the stem and branches of a plant. This is generally true for the same species; we know, for instance, that the more numerous the branches of an Oak are, the more abundant are its roots; more than this, it is known that the strongest roots in the oak correspond with its strongest branches. But if we turn from one species of plant to another, we find, not without surprise, that the roots of the *palms* and *pines* bear little proportion to their height; whilst some plants, such as Lucerne, Bryony, and *Ononis* (Cammock), are provided with enormous roots in proportion to the small dimensions of their stems.

If roots do not show in their ramifications the same regular and unvarying arrangement that we see in leaves and boughs, the cause

but the result of design. The composition of the soil varies singularly in different parts of the globe. In order that every point of the surface of the earth should be covered with vegetation, and that no part of it should be without that incomparable adornment, roots must take very varying shapes in order to accommodate themselves to these varieties in the composition of the soil. In one place the soil is hard and stony, heavy or light, formed of sand or clay; in another it is dry or moist; elsewhere it is exposed to the heat of a burning sun, or swept, on the heights, by the violence of the winds and atmospheric currents; sometimes it is sheltered from these movements of the wind in the depth of some warm valley. Roots, hard and woody, separated into strong ramifications, yet finely divided at their terminations, are requisite for mountain plants, whose roots are to live in the midst of rocks or between the stones, in order that they may penetrate between the chinks of the rocks, and cling to them with sufficient force to resist the violence of hurricanes and other aerial tempests. Straight tap-roots and slightly branching plants are fit for light and permeable soils. They would not suit close, clayey, and shallow soils. Such districts are suitable for plants whose roots stand horizontally just under the surface of the soil.

These considerations are of great importance to the cultivator, who, if he would propagate plants successfully, must carefully study the nature of the soil, and choose for his experiments plants having roots adapted to it.

Two modifications may be found in the two classes of roots of which we have been speaking. It sometimes happens that these roots form themselves into masses more or less voluminous, full of nutritive matter, which is destined to nourish the plant or to favour its increase. Common examples of this structure are presented to us by the *Orchis mascula* of our meadows and woods, the Anemone, Ranunculus, and Dahlia of our flower gardens. These roots are called *tuberous* when they take the form of the roots of the Dahlia (Fig. 9), or *tubero-fibrous* when they take the form of those of the Orchis (Fig. 10).

These enlargements of the root have a special use in the life of the plant. It is their function to accumulate, in the lower part of the vegetable, supplies of nutritive matter, consisting chiefly

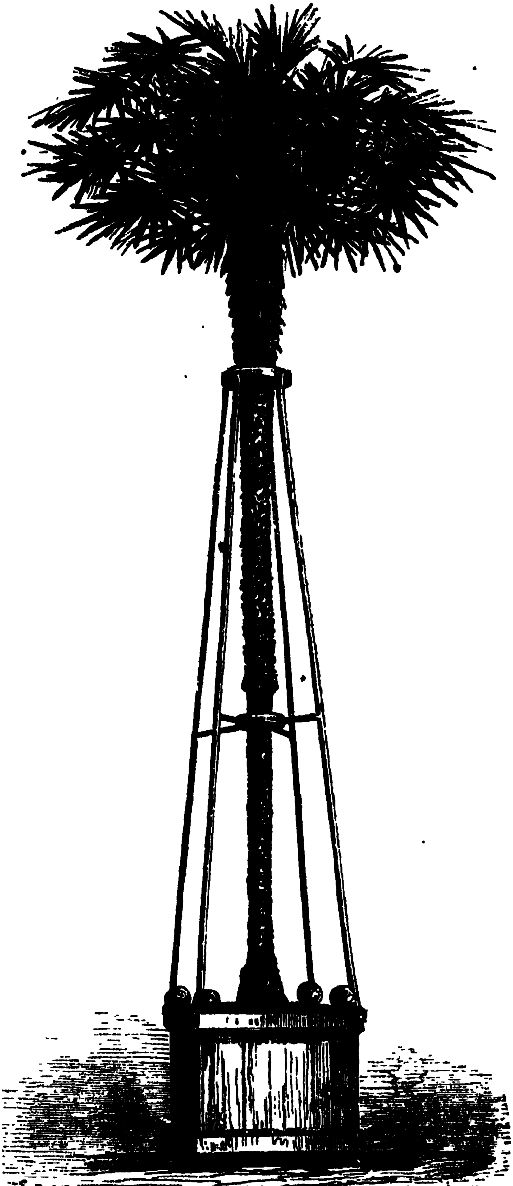

Fig. 8.—Fan-palm at the entrance of the Amphitheatre at the Jardin des Plantes.

supported rear their lofty heads, charged with their fan-like tuft of leaves (Fig. 8).

Some acquaintance with the form of roots will soon find its practical uses. In watering a plant, it is necessary to pour in the water at the foot of the stem, if it is tap-rooted; on the contrary, if the root is fasciculated, it should be poured out at some distance from the stem, in order that the spreading roots may receive the benefit of the water. In the cultivation of plants we manure the surface of the soil, or of the deeper beds, according as the plant has tap roots or fasciculated roots. In scientific farming a plant with fasciculated roots which exhausts the soil on the surface, is succeeded by a plant with a tap root, which seeks it nourishment at a greater depth in the soil.

This diversity in the structure of roots is not the work of chance,

caudex. This is the fasciculated root, of which the Melon (Fig. 7), the Wheat-plant, the Lily, and the Palms are examples.

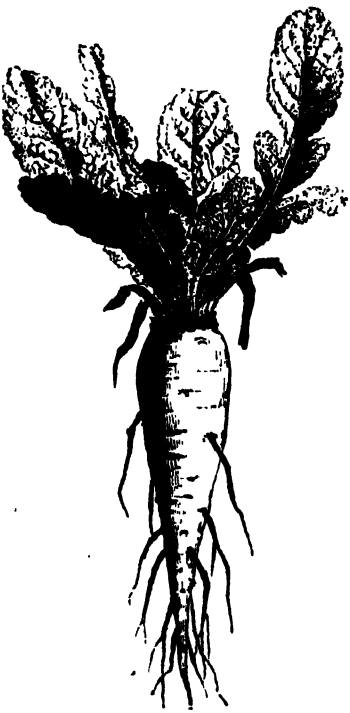

Fig. 6.—Tap-root of the Beet.

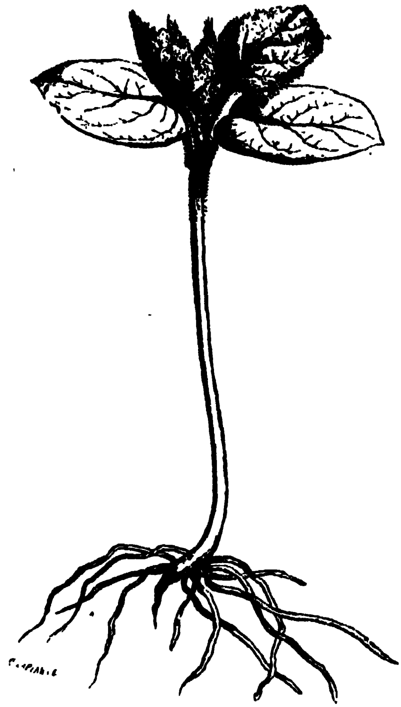

Fig. 7.—Fasciculated root of Melon.

This difference in the structure and constitution of the root must be taken into consideration under a great number of circumstances. The old Fir-tree firmly anchored in the ground by its deep and spreading roots, braves the most violent storms, and even on the mountain-top resists the most terrible tempests. But the Fan-palm, whose fasciculated roots, spread themselves horizontally in the sand, is overthrown, beaten down by the wind, when it has reached the height of five or six feet. If the stem of this palm be artificially supported, it may attain, even in our climate, to a height of fifty or sixty feet. In front of the great amphitheatre in the Museum of Natural History at Paris, two Fan-palms thus

forms tufts or branches of a delicate pale green, attaching itself to apple-trees, poplars, and a number of other trees. Some roots appear, moreover, to have no other function than to fix the plants to the soil: they seem to contribute nothing to their nourishment.

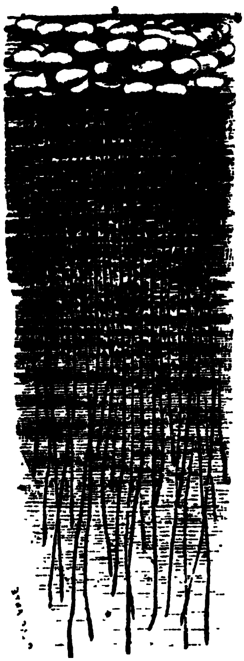

Fig. 5.—Duck-weed (*Lemna*).

In the Museum of Natural History of Paris, there has been for some years a magnificent Peruvian cactus, of an extraordinary height, which has been growing vigorously, throwing out enormous branches with great rapidity. Its roots are shut up in a box of forty inches square, filled with earth, which has never been renewed and never watered. It is therefore evident that in this case the roots have little to do with the nourishment of the plant. Other instances confirm these inferences. "In this country, where six months passes without a drop of rain falling," says Auguste de St. Hilaire, "I have seen, during the dry season, cactuses covered with flowers, maintaining themselves on the burning rocks by the aid of a few weak slender roots, which sink into the dried-up humus which has found its way into the narrow clefts of the rock." Nevertheless, most plants are nourished, to a large extent, through their roots. Other plants, as the Screw-pine (*pandanus*), and the Mangrove-tree (*rhizophora*, root-bearer, from its habit of emitting roots from the stem, which descend until they reach the ground, when they bury themselves in the soil),—these are sometimes called—not very correctly however—aerial roots.

The multiplication of roots takes place, sometimes by their elongation and thickening, as in the Carrot, Turnip, and Beet (Fig. 6). When short and slender, natural rootlets, named *radicles*, are emitted, or rootlets which accompany the descending body; this is the tap-root. Sometimes the root is entirely composed of *axils*, more or less numerous, and nearly of the same size, which unite at the *collum*, or point of juncture, of the stem and

tangled, disordered mass! These organs, so little favoured in their appearance, have, however, very important functions in the order of vegetable action.

The general form of roots is conical, the thicker part being termed the *caudex* or stock; the tender and delicate point of the cone, from its soft yielding substance, the *spongiola;* the thread-like filaments it throws out in all directions are the *febrilla,* which is somewhat inflated, and consists of a series of small cells, the ducts of which convey the food of the plant from the spongiolles to the caudex of the root. Besides this function, it is now pretty well established that the spongiolles possess the power of ejecting effete or deleterious matter, and on this property of plants cultivators of the soil formed the system of rotation cropping; that which, in course of time, renders the soil unfit for one crop until it is renovated, being harmless, if not beneficial, to others.

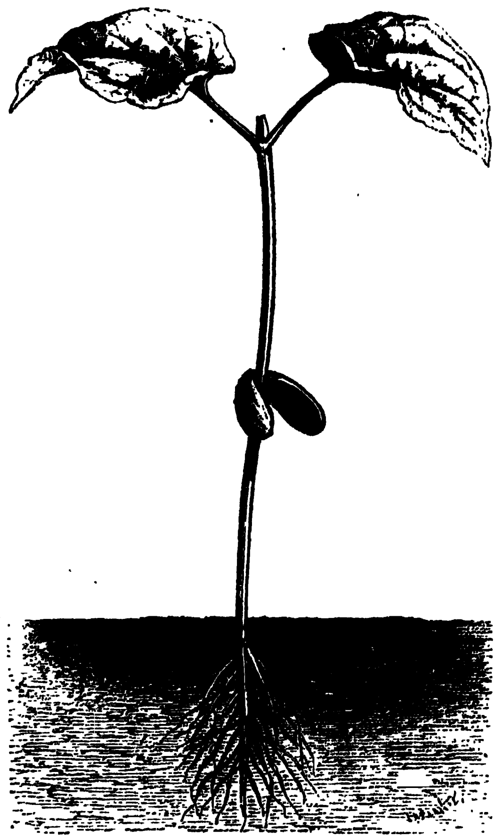

Fig. 4.—Young Haricot.

But all roots are not planted in the soil. There are some plants which take root in water, as the Duck-weed (*Lemna*), Fig. 5, which never touches the earth. Others nourish themselves on the tissues of other plants, as the Misletoe, a singular parasitic plant, which

by this admirable arrangement of nature permitting us to contemplate the wonderful results, but without as yet enabling us to comprehend the strange mystery. A vegetable in miniature, the counterpart of the first, will, after a time, slowly reveal itself to the observer; in the mean time two parts, very distinct, make their appearance: one, yellowish in colour, already throwing out slender fibrous shoots, sinks farther into the soil—this is the racine *radicle* or root; the other, of a pale greenish colour, takes the opposite direction, ascends to the surface, and rises above the ground—this is the stem.

Fig. 2.—Haricot bean (*Phaseolus vulgaris*).

Let us consider at first, in a general manner, this root and stem, with their functions. They are the essential organs of vegetation, without which, when we have excepted certain vegetables of an inferior order, plants, decorated with leaves and flowers, cannot exist.

1. The Root.

The design of the Creator of the world seems to have been to embellish and make beautiful all which was to be exposed to our eyes, while that which was to be hidden was left destitute of grace or beauty. Leaves suspended from their branches balance themselves gracefully in the breathing air; the stems, branches, and flowers are the ornament of the landscape, and satisfy the eye with their beauty; but the root is without colours or brilliancy, and is usually of a dull uniform brown, and performs in obscurity functions as important as those of stem, branches, leaves, or flowers. Yet how vast the difference between the verdant top of a tree, which rises graceful and elegant into middle air—not to speak of the flower it bears: and the coarse mass of its roots, divided into tortuous branches, without harmony, without symmetry, and forming a

Fig. 3.—Haricot bean germinating.

Fig. 1.—Definite root-stock of the Iris.*

THE VEGETABLE WORLD.

ORGANOGRAPHY, OR THE STRUCTURE OF PLANTS.

COMMIT a seed to the earth; plant, for example, a Haricot bean (Fig. 2) at the depth of two inches in moist vegetable soil, and if the temperature is between 15° and 20° R., the seed will not be slow to germinate, first swelling, and then bursting its outer skin, and

* *Fig.* 1 is an example of Rhizome, or underground stem or root-stock; *a*, the parent root-stock, which has generated *b*, which in its turn has generated *c c c;* the rootlets *d* consist of thick adventitious fibres; *e*, young root fibres from *c*, which have just begun to germinate. This kind of root is said to be definite, because its extent is limited; compound, because it consists of separate branches.

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now turn themselves in the direction inverse to centrifugal force, or towards the centre of the wheel. The rootlets, which, under ordinary circumstances, would bury themselves in the earth, and in the direction required by the laws of gravitation, in reality now point in the direction of the force which has taken the place of gravitation.

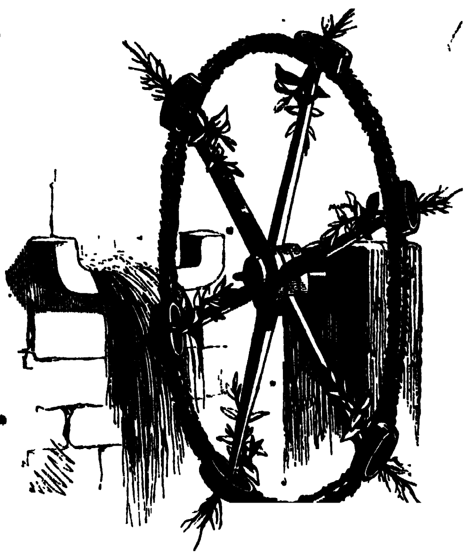


Fig. 18.—Knight's Vertical Wheel experiment.

This curious experiment, carried out for the first time by Mr. J. A. Knight, a former president of the Royal Horticultural Society, has been repeated and modified in France by the ingenious naturalist, Dutrochet. He replaced the vertical wheel by a horizontal one, the force of gravitation acting constantly on the same points of the germinating

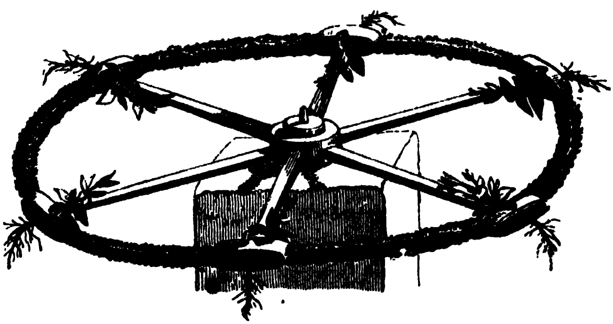


Fig. 19.—Knight's Wheel turning horizontally.

seed; but as this seed is exposed at the same time to the action of centrifugal force, produced by the movement of the wheel, the

rootlets follow an intermediate direction between a vertical one, which would be determined by the power of gravitation, and a horizontal one, resulting from centrifugal force. As the movement communicated to the wheel is increased in rapidity, the angle made by the root with the plane of the wheel becomes more acute also. When in a line with the wheel, the root is horizontal, and its direction outside the wheel.

The influence of gravitation in directing the course of the root is put beyond doubt by these curious experiments.

It must, however, be acknowledged that all is not mechanical in this tendency of roots to bury themselves in the earth. There exists beyond any doubt a real organic faculty belonging to the living plant.

If we compare a transverse section of the stem, with one cut from the root of one of our forest trees, the difference between the two parts of the vegetable amounts to very little. The exterior of the root is covered with a bark, very similar to that on the trunk of the tree, only the *parenchyma*, or cellular tissue, is never green in roots. The interior is a woody cylinder, composed of fibres, vessels, and medullary rays. Wood, therefore, forms the central portion of the root, which is almost always unprovided with the kind of vessel known by the name of duct, or *tracheæ.** It is chiefly in this last particular that the root varies from the stem as regards its structure. When considering the stem in the next chapter, we shall get to understand these woody fibres and medullary rays.

Roots increase their growth at their extremities only. These extremities are always fresh, and always furnished with porous and soft cellular tissues, the *fibrilla*, and their terminal point th *spongiala*, whose function is the absorption of the liquids or gase which are destined to penetrate into the interior of the vegetable. This absorption is facilitated and increased by means of the fine elongated hair-like fibres attached to all roots. Fig. 20 represents the terminal part of a root, as seen in the microscope. The true seat of absorption is not situate, as one might suppose, at the

* One of the many striking analogies which exist in the structure of animals and vegetables. The tracheæ of insects very closely resembles the vegetable spiral duct.

extremity of the radicle, that is to say, at the points, but rather at a certain distance from the end, in the part marked in the engraving by the letter o.

The material which these organs take up from the soil in order to pass them into its system must either be gaseous or liquid. Solid bodies however attenuated, or however subdivided, even when held in suspension in water, cannot penetrate into the infinitely narrow channels which the extremities of the root-fibres present. All substances so absorbed must therefore be in a state of chemical dissolution in the water. The more important of these substances for the purposes of vegetation are the salts of potassium, of soda, of lime, ammoniacal compounds, and carbonic acid gas dissolved in water.

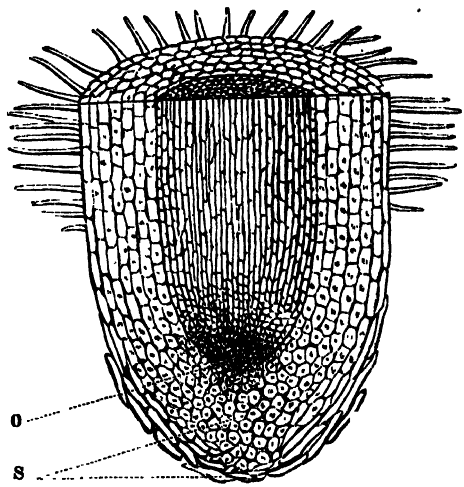


Fig. 20.—Vertical section of the extremity of a root, seen in the microscope.

But what is the mysterious power which produces the operation of absorption in plants, this operation by which a liquid from the exterior enters and traverses an organ already gorged with liquids? Botanists have now agreed that this result is due to the triple influence, to the successive or combined action of *endosmose* of *capillary attraction* and a *determinate attraction* in the leaves. Let us explain ourselves.

Take a small vessel, A, Fig. 21, formed of animal or vegetable membrane, containing sugared or gummed water, and plunge this vessel into another containing pure water. The liquid gum contained in the small vessel will be heavier than the pure water which surrounds it. This unequal density creates immediately a double current across the walls of the vessel; the pure water flows towards the denser gum water, while the other flows in the opposite direc-

tion, the least dense liquid passing, however, more rapidly than the other; and if we adapt a vertical tube to the vessel, B, we see it gradually rising in the tube. This curious result is called Endosmose by chemists. This phenomenon, which has been carefully studied by chemists and botanists, is visibly in action in the vital functions of plants. The fibrous extremities of vegetables are filled with liquids and saccharine matter heavier than the water which surrounds it in the soil. By the phenomenon of Endosmose the infiltration, or passage of water through the thin cellular exterior tissues takes place; thence the water rises up through the interior vessels of the plant, as we have seen it rise in the tube of the *Endosmometer*. In this manner the first movement of ascension is produced.

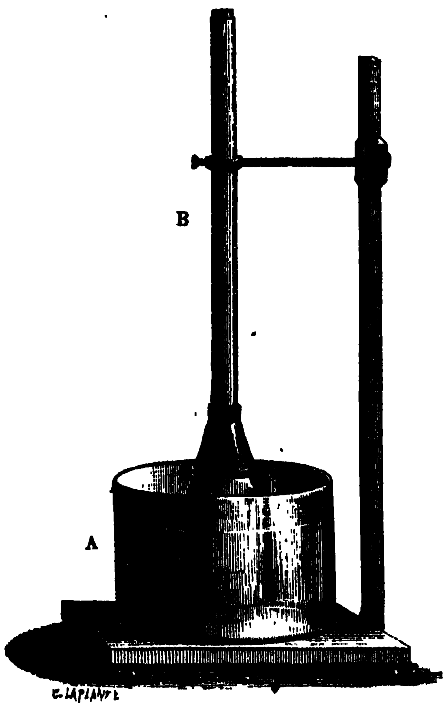


Fig. 21.—Endosmometer.

But the mere power of *endosmose* would not force the foreign fluids very far up into the vessels of the plant. A second force which here intervenes singularly accelerates their upward progress. When a liquid has begun to penetrate, by means of *endosmose*, at the extremities of the root, the density of the liquid contained in these radicular extremities being thus diminished by dilution, there is a current formed for them in the interior of the root. After that the force known in physics by the name of *capillarity* promotes the ascent of the liquid in the more elevated part of the root. The internal walls of each cell of the root exercise on the liquid which it contains the force of *capillarity;* in other words, an

attraction which partly destroys the effect of gravitation, and determines the ascent of the liquid to a much higher level than it would attain in a larger tube. The phenomenon of capillarity is, then, added to the action of endosmose to favour the absorption of liquids by the radicular extremities.

When the plant is furnished with leaves, there is a third force which unites with the two others in accelerating the absorption. The leaves are the seat of a considerable evaporation. The water dispersed into the atmosphere in the form of vapour leaves a partial vacuum in the vessels; this vacuum is immediately supplied by the afflux of the liquids flowing from the roots. In this manner leaf action is produced; this is a sort of suction which draws towards the leaves an afflux of liquid, which the radicular absorption is constantly compelled to supply.

Thus *endosmose*, *capillarity*, and *suction*, in the upper part of the plant, are the physical forces which appear to play a part in the absorption carried on by roots. We must, besides, in order to explain the great phenomenon of the life of plants, bring in a force very superior to all these physical actions. This is the action of *vital force*, that secret and invincible power which God only bestows and of which *He* alone directs the results.

II.—The Stem of Plants.

The stem is the axis of the ascending system of the vegetable. It is furnished at intervals with *vital nodes*, or eyes, from which spring the leaves, buds, and branches, arranged in a perfectly regular order. The *root* presents nothing of a similar nature. This characteristic enables us easily to distinguish in the vegetable axis between that which belongs to the stem, and that which is peculiar to the root. The stem is that part of the plant which, rising into the air, produces and supports the branches, boughs, leaves, and flowers. Through its tissues the liquids inhaled by the roots penetrate into the interior of the vegetable for the purpose of supplying it with nourishing juices, increasing its growth and maintaining its vital functions.

The form, size, and direction of the stem depend on the part

which each plant has to take in the vast vegetable population which covers and adorns the globe. Plants which require to live in a pure and often renewed air, have a straight stem, either robust or slender, according to their individual habit. Where they require a moist and denser atmosphere, when they have to creep along the ground or to glide among the brambles, the stems are usually long, flexible, and trailing. If they have to float in the air, supporting themselves on plants of more robust growth, or to hang suspended from forest trees in graceful festoons and light garlands, they are provided with flexible, slender, and pliant stems, which enable them to embrace with their tendrils the trunks of trees or shrubs. Thus, nature fashions the outward forms of plants according to the part which they are intended to fill, and according to the functions which have been allotted to them.


Fig. 22.—Bindweed.

Nothing is more variable than the appearance of the stem in vegetables and trees; in their infinite variety they sometimes present to us perfect types of beauty and elegance. Sculpture and painting have borrowed from the trunks of certain trees, models of architecture at once elegant and majestic; types which have been handed down to us from the most remote antiquity, and which are still the models in use. Man has discovered in vegetable forms his first designs for adornment, construction, and grace. The stem of the Palm-tree and the Date-tree, and the leaves of the Acanthus, formed a model for the majestic columns of the Corinthian order; the leaves of the vine and the natural garlands of young climbing

plants furnished ancient art with types of ornamental design, which are still preserved in modern architecture.

Fig. 23.—Trunk of an Oak.

In botanical language, the stems of plants are not always called by the same name. The stems of trees, as the Oak (*Quercus*)

Fig. 24.—Culm of the Rye.

in our climate (Fig. 23), bear the name of trunk. The stems of the *Gramineæ* (grass family), commonly cylindrical, and nearly always indented by annular knots from which the leaves spring, are called the *culm* (Fig. 24); those of Palm-trees, which resemble columns crowned with a chaplet of leaves, are called *stipes* (Fig 25)—terms, however, which botanists rarely employ.

The thickness and height of stems vary very much among vegetables. Whilst the trunk of certain exotic trees, as the monstrous Baobab, attains gigantic dimensions, the stems of many of our spring plants, as those of the Sassifrage, and the Early Whitlow grass (*Draba verna*), scarcely attain the thickness of a thread. "While crossing the Rio Claro, a river in the province of Goyas, in Brazil," says A. de Saint Hilaire, "I perceived growing on a rock a plant not more than three lines in size, which I took at first for a moss. It was, however, a species of a superior order, and provided with a reproductive apparatus like our oaks and beeches. By the side of it gigantic trees reared their majestic heads to the height of a hundred feet."

Accordingly as stems last one

year, two years, or more, they are called *annual*, *biennial*, or *perennial*. Aborescent stems which live a greater or less number

Fig. 25.—Stipe of the Palm-tree.

of years, and form solid wood, are said to be *ligneous*, or wooay. The soft stems of annual, biennial, or perennial plants are called

herbaceous; and the stems of the leek, the cactus, and some of the euphorbias, are called *succulent*. Fig. 26 represents the stem of a cactus in flower.

In a great number of plants the stem rises firm and straight into the air. It is then called an *upright stem*. There are some, on the contrary, which have not consistence enough to keep themselves upright; they stretch along the ground, only lifting up their heads, so to speak; these are procumbent stems; or, being quite prostrate, they are fixed by adventitious roots or sunken, and are called *creeping stems*.

Fig. 27 represents the procumbent stem of the *Veronica*

Fig. 26.—Stem and Flowers of a Cactus.

officinalis. Others, like the *ivy*, hang on to neighbouring bodies by the aid of their suckers or adventitious roots; or, like the bindweed, they entwine themselves spirally round trees. The first are called *scandent stems*, the latter *volubile*.

Volubile stems do not all twine in the same manner; but the direction of twining of stems is invariable in the same species, and

even resists efforts made to change it. Some, like the Bindweed (Fig. 22), if we suppose that they are twining round our own body,

Fig. 27.—Procumbent Stem of Veronica officinalis.

go from right to left; others, as the Hop (Fig. 28), go from left to right. "The Lianas, which in the primitive forests produce the most marked varied results," says A. de Saint Hilaire, "and which impart to these forests their most picturesque beauties, are ligneous plants, some of them *scandent*, others *volubile*. These are the Bigonia, Bauhinia, Cissus, &c., and though they all need a support, yet each plant has a bearing which is peculiar to itself. Some lianas resemble wavy ribbons; others are twisted, and describe large spirals. They hang in festoons, wind about among the trees, leap from one tree to another, and entangling themselves together, forming masses of leaves and flowers, so that the observer finds it difficult to distinguish to which tree it belongs."

These Lianas of the American forests, are very imperfectly represented in our climate by the Ivy, the Honeysuckle and the Clematis, the Bindweed, and the Hop-plant. The stems of which we have spoken are *aerial*; but there are subter-

raneau stems. The Solomon's Seal (Fig. 29) presents a subterranean stem, thick, fleshy, whitish, and indented on its upper surface with scars corresponding with the bases of old aerial stems (thence the name of *seal* which this plant has preserved). This subterranean stem terminates at its foremost extremity with a leafy and flower-bearing axis, placed behind a terminal bud, which will develop itself the following year. Many plants, as the iris, flowering rush, water trefoil, and *carex*, alike present subterranean roots. Fig. 30 represents the subterranean root of the *Iris germanica.*

Fig. 28.—The Hop-plant.

These roots have received from botanists the name of *rhizomes*, from *ῥίζωμα*, a root or root stock. They creep obliquely or horizontally under the surface of the soil, and vegetate at their most advanced point, whilst the hinder part is gradually destroyed by age. This mode of existence in subterranean roots is well exemplified in Fig. 31, which represents the growth of a sprig of *Carex*, so called from *careo*, "to want," its upper spikes being seedless. In this engraving is shown the horizontal and creeping axis, which represents at once scales or modified leaves and root-fibres, and which sends out leafy shoots at intervals. The shoot 1 is only one year old,—in the next spring it will assume the form of the shoot 2; the following year it will bear flowers and fruit, as in 3; the production of fruit will mark the term of its existence, as shown in 4. Fig. 32 is the Maize plant (*Zea Mays*).

Another very remarkable kind of subterranean root is that which forms the central or essential part of *bulbous* plants. Cut

the bulb of a hyacinth or lily longitudinally; it will be observed that it is composed of a fleshy surface, more or less conical in the upper part, and truncated below, constituting a short stem, with *internodes* or knots placed very close together. This surface gives rise, at its upper face, to fleshy scales, which are modified leaves pressing one against the other, and to a central bud formed of leaves and rudimentary flowers, whilst from its lower face spring the root-fibres. In the Hyacinth (Figs. 33 and 34) the scales form

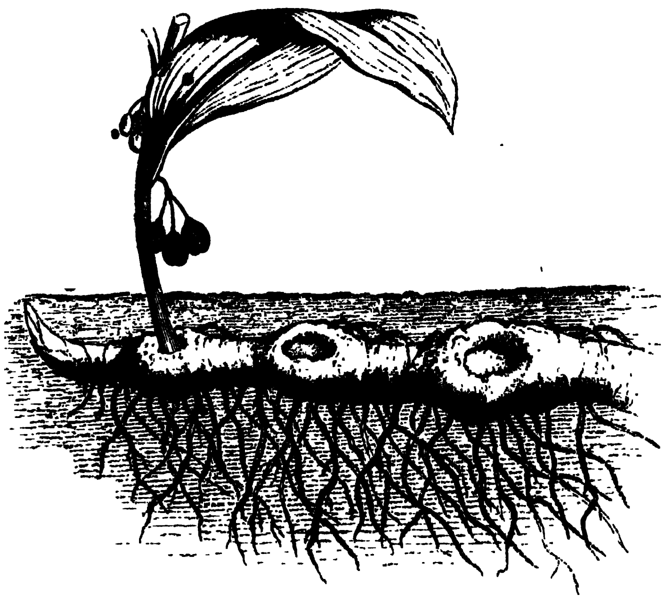


Fig. 29.—Solomon's Seal.

complete sheaths, which grow one over and round the other, and its bulb is *tunicated*. In the Lily (Figs. 35 and 36), the scales are smaller, and overlap one another like the tiles on a roof of a house; its bulb is *scaly*. In the Crocus (Figs. 37 and 38) the base of the stem is extremely broad, of a globular or depressed shape, and only produces a few thin and membranous scales; its bulb is said to be *solid* and *superposed*, several stems rising out of its upper surface.

The *rhizome* and the *bulb* are only distinguished from each

other by the length of surface (as shown in the vertical section) and the fleshy consistence of the subterranean leaves.

We now have to consider the structure of stems in different

Fig. 30.—Subterranean stem of Iris germanica.

kinds of vegetables. In order to arrive at a correct idea of their structure let us consider, first, the stem of *forest* trees; secondly, that of *palm* trees; thirdly, that of *aborescent* or tree *ferns*.

An acquaintance with the ligneous stems of forest trees is interesting in more than one respect. Nature has collected all her powers to give to trees the strength necessary to resist the dangers and the causes of destruction which threaten them. Their wide-

Fig. 31.—Subterranean stem of Carex, with shoots for four years.

spread and bushy summits, the immense mass of foliage which they support, and the great height to which they attain at the end of their growth, expose them to the fury of tempests. Their trunks must be immovably solid, in order to brave all the violence

Fig. 33.—Bulb of the Hyacinth.

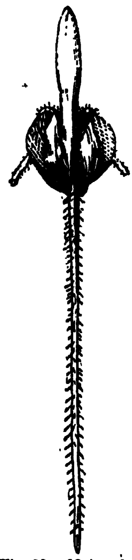


Fig. 32.—Maize plant.

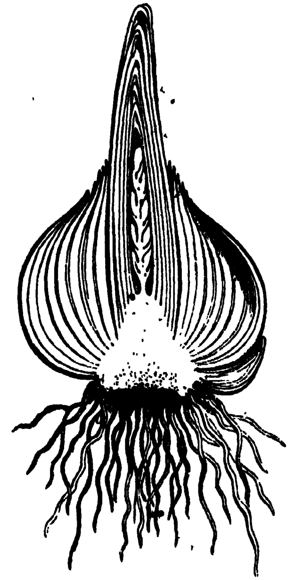


Fig. 34.—Vertical section of the Hyacinth.

Fig. 35.—Bulb of the Lily.

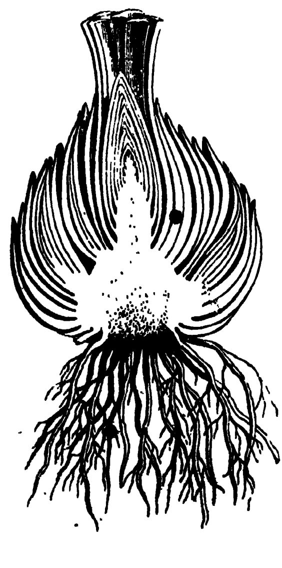


Fig. 36.—Vertical section of the Lily.

of the winds. Nature has constructed them with the particular aim in view of resistance. Year after year, she accumulates in their interior successive layers of increasingly solid substance. In proportion as the vegetable increases in size and needs a more powerful support, the interior concentric rings, which by their combinations form the strong and compact tissues of our forest trees, are compressed, and more and more consolidated. In its origin —that is to say, at the moment when the young stem, just sprung

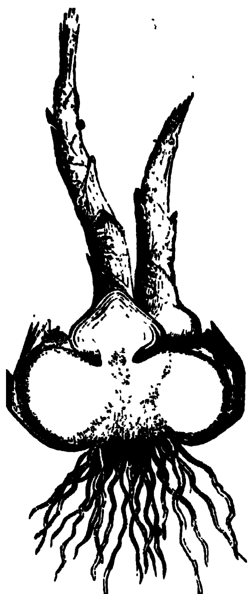


Fig. 37.—Section of a Crocus Bulb.

Fig. 38.—Bulb of the Crocus.

up out of the ground, begins to rear itself in the air—nothing is observable in its interior except an abundance of pith, surrounded by its breathing vessels (*tracheæ*). But as the plant increases, new elements interpose between the pith and the bark; and when the trunk has lengthened and strengthened, it presents an internal structure complicated enough, and well calculated for resistance to all outward forces. A mere glance at the section of a log of fire-wood, informs us that the stems of forest trees present three

essential parts, namely, pith at the centre, surrounded by woody fibre, and exterior bark. Let us examine more closely each of these parts in an indigenous tree.

The *pith* forms a sort of column in the centre of the woody axis, as in Fig. 39, which represents an horizontal section of the trunk of the *maple*. In very thick and old stems, the diameter of the pith appears very small, and for a long time it was even supposed that in the trunk of very old trees, pith completely disappeared. But it is not so. It is asserted that according to exact measurement and observation the diameter retains perceptibly and invariably the same proportion from the time when the young ligneous axis has begun to solidify, up to the period of its maturity. The pith is formed by a combination of *cellules*, or cells, to use the scientific term.

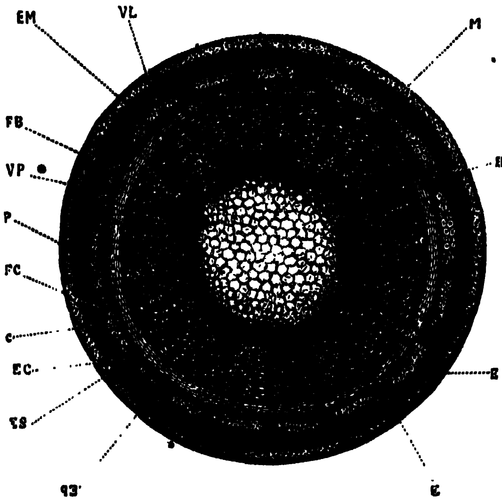


Fig. 39.—Horizontal section of a Maple-tree.

Cells are simple, primitive organs, which are present in every vegetable structure. It is a sort of sac or cavity, surrounded by walls of transparent membrane; a vegetable cell, in short, is well represented by a soap bubble. A cellular mass without intercellular spaces may be compared to an aggregation of soap bubbles, pressed against each other. The cavity is completely closed; sometimes it is empty, sometimes it is filled with vegetable matter. Fig. 40 represents the transverse section of a cluster of young vegetable cells; they are, as we see, nearly circular in form. When they have become larger, they mutually compress each other, so that their form, at first nearly circular, becomes polyhedral, as represented in Fig 41.

The pith of young-trees, as represented in Fig. 40, is, as we have

said, an aggregation of cells, at first nearly circular, which become polyhedral from compression as the stem increases in size, and this is the *medulla* or medullary tissue of which the central column of

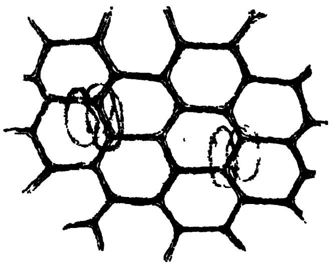


Fig. 40.—Polyhedral tissues of the Pith.

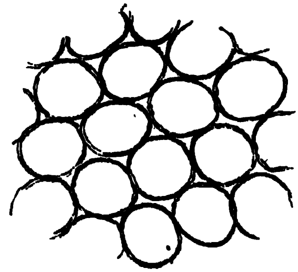


Fig. 41.—Prismatic cells of the Pith.

most forest trees is formed. This medullary tissue is totally deficient in vital energy in its central parts.

Between the pith and the bark we find concentric zones, which bear the name of *ligneous* layers, the aggregation of which form what is commonly called *wood*. If we examine the trunk of the oak, the apple, or the cherry-tree, a very sensible difference is observable between the innermost woody layers, which are of a darker colour and denser tissue than the exterior ones, which are, on the contrary, of a paler hue and softer texture. In Fig. 42, which represents a vertical section of an *oak* of eighteen years' growth, the *sap-wood* (*alburnum*) is represented by the letter A, the wood by the letter B, the bark by the letter E. The pith is in the centre, with the starry appearance, which, in the oak, it often presents. The *medullary rays*, to which we shall now return, are very apparent in this section. The name of sap-wood (*alburnum*) is given to the outside layer of wood, and that of heart-

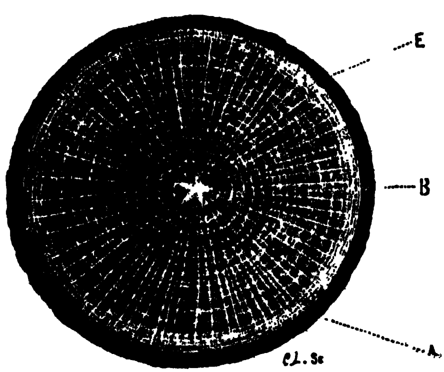


Fig. 42.—Vertical section of the Oak of eighteen years' growth.

wood (*duramen*) to the innermost ones. In some trees, and notably in those which are not hard grained, as the poplar, willow, and chestnut, the line of demarcation between the wood and the sap-wood is slightly marked. In hard woods, on the contrary, it is strongly defined. Thus, in ebony the heart-wood is of an intense black, whilst the sap-wood is white; in the Judas tree the heart is yellow and the sap-wood white; in the *Phillyrea* (mock privet) the heart is red and the *auber*, or sap-wood, white.

Workmen who work in wood are well aware that the sap-wood is much less solid than the heart, and that the latter only ought to be employed for wood work. Examined in masses, the *ligneous* layers are hardest at the centre; but (Fig. 43, woody fibres magnified) studied individually, each layer is more compact towards the exterior. Neither are all the layers of an equal thickness, whether compared with each other, or in their several parts.

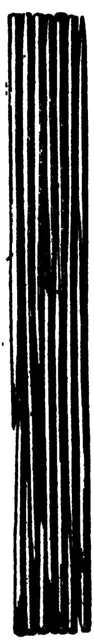


Fig. 43. Woody fibres magnified.

The substance which prevails in the wood, and that which gives it its hardness, is the *woody fibre*, represented in Fig. 43. This is an elongated cellular substance, terminating in a point at the two extremeties, as there represented. The walls of the cells of which it is composed are very thick, generally so thick that their interior cavity is much reduced. This thickness, as well as the colouring of the fibres, varies with the different parts of wood, with the age of the stem, and even with the nature of the tree that is under examination. The woody fibres press end to end one against the other, and become so entangled as to constitute what is called a *fibrous* tissue, very difficult to pierce when cut across, but, on the contrary, easy enough to divide when cut longitudinally.

This *ligneous fibre* is not the only element composing wood. Cut transversely a branch of the *vine* (a plant in which the substances we are going to speak of acquire a considerable volume), and apply the eye to one end; if the branch is straight, you will see the light at the other end. Examine the surface of the section of the branch, either with the naked eye or with a magnifying glass, and it will be observed that it is perforated with a considerable number of small

holes, of unequal size. If you introduce a hair or a very fine thread into one of these openings, you will succeed in passing the thread to the other end of the branch. Continuous canals, therefore, exist in the interior of the vine branch. These canals, formed of a membrane peculiar to them, are the *sap vessels.*

If a portion of the transverse surface of a log of *oak* or *elm* is neatly cut, it will be observed that the inside edge of each ligneous zone presents a certain number of small holes, clearly perceptible to the naked eye, or at least with the help of a common lens: these are the orifices of rather voluminous vessels. In the centre of the ligneous zone the vessels are much smaller, and sometimes almost imperceptible. Examine the wood of the *hornbeam, lime,* or *maple-tree,* in the same manner, and it will be observed that the internal edge of the zone is not now occupied by large vessels, but is almost entirely riddled by the orifices of smaller and more evenly-sized vessels, which become indistinct towards the external edge of each zone. These are called the *lymphatic vessels.*

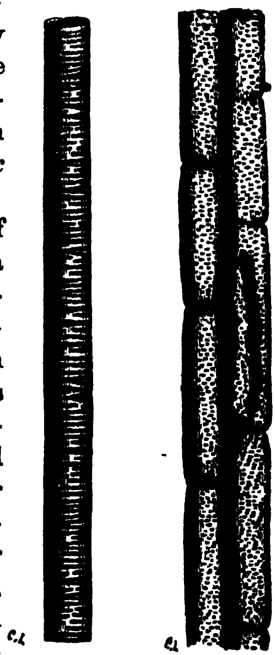


Fig. 44.—Wood-vessels (punctated and striated vessels of the Melon).

What is the structure and function of these different vessels? They resemble a cylinder, with obstructions placed at intervals, more or less marked, having also transverse lines or diaphragms intersecting them at brief distances. Sometimes the remains of these diaphragms correspond in the interior of the vessel to these contractions and lines. In one word, these cylinders appear formed of cells, placed end to end, the partitions of which have been destroyed. Their exterior walls show certain points, rays, and net-work, presenting very beautiful forms, which result from the unequal thickness of the walls, inequalities which are the result of certain laws regulating their existence. Fig. 44 represents these *vessels* in the *melon.* From the peculiar appearance offered by their external covering, which

is marked with small dots, furrows, and streaks, they are called *dotted vessels* and striated vessels.

There is a particular part of the wood, however, in which the vessels are of a very different nature from that just indicated. We find them round the pith, in the innermost portion of the woody circle, and never anywhere else. These vessels, with the slender fibres which accompany them, have received, and most improperly retained, the name of the *medullary sheath.* We say improperly, for here there is only a combination of vessels, and no *sheath.* The image which this word recalls is not of a nature to enable us to understand the important modification of structure which belongs to the innermost vessels of the woody circle, which are the air-vessels, or *tracheæ,* of the system.

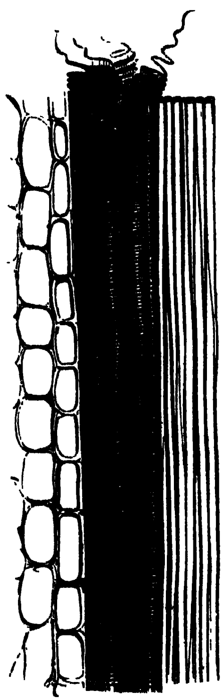


Fig. 45.—Tracheæ of plants surrounded by pith and woody fibres.

Fig. 45 represents the central part of a piece of tree as seen in the microscope, with a very strong magnifying power. In this central portion, which has been most improperly called the *medullary sheath,* we see the *tracheæ,* that is to say the air-vessels, of which we are speaking, on one side touching the pith at the centre of the stem, on the other side in contact with the woody fibre.

The structure of these tracheii is very singular. They form masses of elongated fibre, which is still more slender at the extremities. Any one would believe at the first glance that these vessels were very finely streaked diagonally, and that their external coat is continuous; but if the slightest pulling is used towards them, they unroll like a spiral spring. These vessels are, then, formed of a spiral thread, twisting round a cylinder with contiguous spiral turns, which are joined together by a membrane, which is so extremely thin, that it is difficult to find the traces of it when the spiral tube has been unrolled.

There is one final peculiarity which marks the section of the

stem of one of our forest trees. It is that assemblage of diverging lines which bear the name of *medullary rays*. In a transverse section of the stem of a tree, the mass of wood is traversed by a great number of radiating lines, all of which start from the back and converge towards the pith, or medulla. But they do not all reach it; there is a certain number which stop short in some of the layers, more or less deep in the trunk, without reaching the pith. These radiating lines result from the transverse section of the cellular laminæ, the edge of which we thus see, and the length and thickness of which are variable.

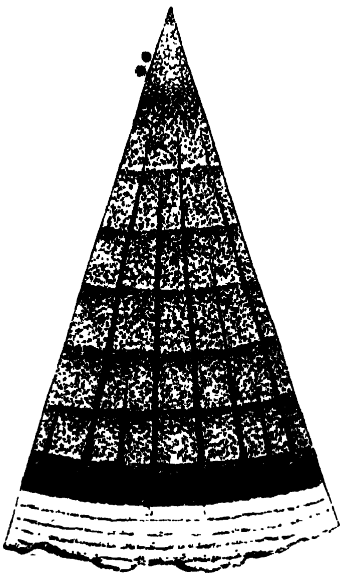


Fig. 46.—Medullary rays of the Cork-tree (horizontal section).

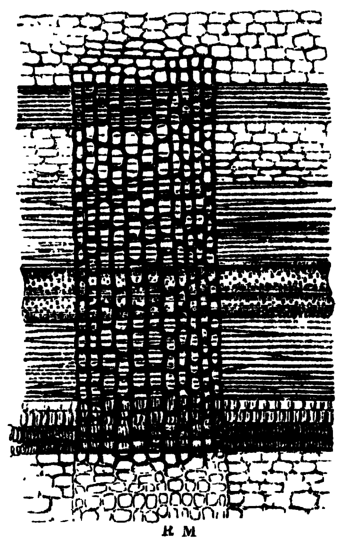


Fig. 47.—Medullary rays of the Maple.

Fig. 46 represents the medullary rays of a trunk of *Cork-tree* (*Quercus suber*), in a transverse section. Fig. 47 shows the same organs in a similar section of the stem of the *Maple*, magnified by means of the microscope. In this last, R M are the medullary rays, which go from the centre to the circumference of the stem. The *tracheæ*, the *ligneous fibres*, and the vessels, are represented by the

letters T, FL, V, and the pith by the letter M. To make this more clear to the reader, we avail ourselves of an illustration borrowed from Mr. Christopher Dresser's "Rudiments of Botany" (Fig. 48), in which A is a horizontal section of an exogenous stem, that is, of a stem consisting of pith, wood, and bark, which is enlarged by external additions. *a b c* are the cellular mass of the stem, in which bundles of woody fibre, *d*, have been deposited. By the disposition of these bundles, the cellular matter has become divided into a central portion, *a*, which is the pith, an outer portion, *c*, which is the bark, or corticle, and the plates, *b*, intervening between the bundles of wood-fibre which connect the bark and the pith; these are the medullary rays or plates. B is the section of an older stem, in which a bundle of woody fibre has been deposited between each of the older bundles. *a*, pith, *b*, medullary rays, *c*, cortex, or bark, *b*, bundles of wood-fibre.

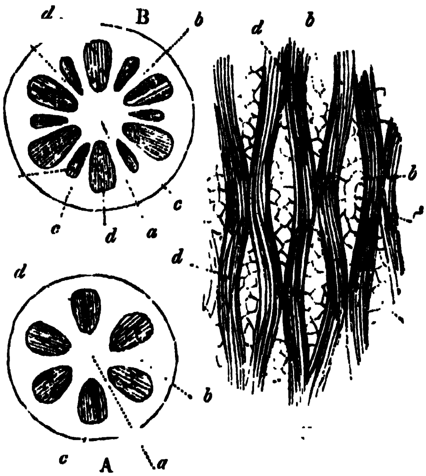


Fig. 48.—Sections of an exogenous stem.

The vertical section C represents a portion of a stem with the bark removed, showing that the bundles of fibre *d* do not descend vertically through the cellular matter *b*, but in waved lines, dividing the cellular into lenticular masses, which form the medullary rays or plates *b*.

Most trees are provided with *medullary rays* of only one kind. A few only present thick and thin rays together. Thus in the *Oak* or the *Hornbeam* we find both thick and thin rays, whilst in *Willow* and *Maple* the rays are visibly equal.

Whilst the fibres and vessels never contain solid nutritive matter, the cells, which, by their junction, form the medullary rays, are the seat of an abundant production of small granules of starch.

The *bark* of trees is essentially composed of fibrous and cellular tissue; but it is easy to understand how varied are the forms, disposition, and structure of these substances, when we consider the extraordinary variety in the appearance of the bark of trees, and the diversity of their products. To explain everything which relates to the structure of the bark, would lead us into details which our space does not permit. We must therefore limit our remarks, and content ourselves with pointing out the principal characteristics of bark, considering generally the trees of our own climate. Briefly, the young stem is invariably covered with a thin cuticle, the *epidermis*. As the stem increases, new bundles of woody fibres are deposited in regular annular layers one in each year, the new layers being deposited outside those already formed. The new layers of bark and wood are thus formed almost in contact, being juxtaposed. The epidermis covers the bark, as it does every other part of the vegetable, but its existence is altogether ephemeral. It is destroyed at an early stage as much by the growth of the vegetable as by the action of external agents. It is otherwise with the *suber*, which forms the next layer, the cells of which are of a cubical form, and are closely united to each other with thin walls or partitions, without colour at first, but afterwards they acquire a brownish colour.

In many trees the *suber* is very slightly developed. But this is not the case with the *Cork-oak* (*Quercus suber*). In this beautiful tree, which furnishes man with one of his most useful commercial products, the *suberous layer* acquires an extraordinary thickness; it is, in short, the substance known as cork, in Latin *suber*, whence the specific name of the tree. When about five years old the suber, which constitutes the greater part of the bark in the cork-tree, begins to make a remarkably quick growth; then all the energy of its vegetation seems to concentrate itself on this part of the tree. New cells appear on the internal face of the primitive zone, pushing the exterior cells which preceded them. Independently of these cells, the successive accumulation of which constitute the mass of cork, others are formed which are shorter, darker in colour, of a flat or plate-like form, which divide the mass of cork into successive zones of growth. This mass attains by degrees to a considerable thickness. If left to itself, it would crack so deeply as to become

unfit for the uses to which cork is destined. It is necessary, therefore, to strip it off before it acquires this hard and fissured appearance.

Barking or peeling off the suber of the *Cork-oak* does no injury to the tree, it is so managed as to avoid injury to the newly formed *suberous layer*, and consequently to the living and underlying layers of the bark. The operation is usually performed when the trees have attained the circumference of ten or twelve inches. The process is performed during the summer months, by cutting a longitudinal notch in the trunk of the tree, intersecting it with several transverse incisions distant about forty inches from one another. The bark is then beat in order to break away the adhesion of the cork to the living layers, and separate the underlying tissues. The bark is then detached in the shape of cylindrical pieces, by means of the handle of an axe, made crooked and thin at the end, as represented in Plate III.

The CORK-TREE is peculiar to hot countries. Algeria possesses several forests of this tree in course of working. Spain has long been celebrated for its produce. The crops of cork are generally gathered, in each forest, once every eight years. The suber lies immediately over a cellular mass of a very different nature. The cells which constitute this layer are polyhedral, they are thicker and more loosely joined, and of a greenish colour. This colouring is owing to the presence of *Chlorophyll*, a matter peculiar to all the green organs of vegetables, which is applied to the internal face of the cellular walls. *Chlorophyll* presents itself, in a mature state, under the form of very small rounded globules, formed of albuminous and fatty matter, sometimes enclosing small kernels of starch in their interior, and appearing to be superficially penetrated by the green colouring matter.

To these three cortical formations a fourth must be added which bears the name of *liber*, and generally appears formed of rows composed of substances with thick and thin walls alternately. The first are fibres of a brilliant white, longer and more slender than the ligneous fibres; their walls are very thick and are often dotted and extremely tough.

The fibres of *liber* render an important service to human industry, since they furnish the materials for ropes, thread, and the strongest

as well as the most delicate cloths. In Fig. 49 the fibres of *Hemp* (*Cannabis sativa*) are shown as a common example of the vegetable substance known under the name of *liber*. These fibres are joined in bundles. The bundles are arranged in concentric circles, frequently joined to one another by anostomose at the extremities, and constitute very thin super-imposed layers, which appear like a sort of tissue, of a more or less loose texture. The whole of these layers together were formerly compared to a book, every leaf of which would represent a layer. Thence the rather unsuitable name of *liber*.

Fig. 49.—Liberine fibres of Hemp.

The stratum having thin walls is formed of cells, which, in spring, enclose fecula and some very remarkable fibres, the very thin walls of which are extensively punctured and covered by wonderfully delicate meshes of network, with interstices often not more than $\frac{1}{1000}$th part of a line in diameter. These fibres, whose physiological functions appear to be considerable, are called *reticulated fibres*.

We cannot conclude our examination of bark without noticing the existence of a product which latterly has singularly occupied the attention of botanists. We mean the *latex* and the *laticiferous* vessels.

In the bark and in the pith of some trees, vessels are noticed very different from those we have hitherto spoken of. They are remarkable at once for their structure and their contents. They are tubes simple or ramified, sometimes completely independent, sometimes attaching themselves one to the other in a continuous length. While the vessels traceable in the woody fibres are formed of cells which can be separated one from the other by the use of proper means, the cells constituting the *laticiferous* vessels are, on the contrary, so intimately blended together that neither mechanical nor chemical action can separate them.

The laticiferous vessels contain a juice, generally coloured. It is easily proved, under the microscope, that this liquid is composed

of an uncoloured serum, holding in suspension numerous and very small globules, to which it owes its colouration. This liquid is called *latex*. But what strikes the observer as above all remarkable, is the circulating movement which is the property of latex. The transparency of the vascular walls, and the presence of the granules, render this movement very perceptible in some plants.

The *latex* is very abundant in certain vegetables. Place on the object-glass of a microscope, and under a thin plate of glass, for instance, a young leaf of *Chelidonium laciniatum*,—better known as celandine, which is said to be so named from its being in flower when the swallows arrive, (Fig. 50), still attached to the branch, or a sepal of the same plant, of which the latex is an orange yellow; or a petal of the *Poppy*, of which the latex is white; or a stipule of *Ficus elastica* (one of the *Caoutchouc trees*); we shall see in all these cases the latex descending in one branch of the net-work of the laticiferous vessels, and ascending in another, returning sometimes to its point of departure, and, in one word, circulating with a rapidity greater in proportion as the temperature is warmer and vegetation more active. Gutta-percha, caoutchouc, and opium proceed from the latex of certain plants.

Fig. 50.—Lactiferous vessels in Celandine.

The elements entering into the composition of the trunks of forest trees are, as we see, rather complex. Having described each in their turn, it will be instructive to bring the whole of them under the eyes of the reader.

Fig. 51 represents a section, both horizontal and vertical, of a trunk of the Maple (*Acer campestre*). The substances embraced by the lines marked No. 1 represent the wood of the first year, those in No. 2 the wood formed during the second year, and those in No. 3 the substances forming the corticle, or bark. In the centre of the stem, M represents the pith, the cells of which are polyhedric. The *tracheæ*, or *medullary* sheath, coming next to the pith and enveloping it on all sides, are represented by the letters

T, EM. Then follow three groups of *ligneous fibres*, FB; the wood vessels, VP, are placed alternately with three groups of woody fibres. The bark, enclosed by the line marked 3, succeeds these substances, the fibres of the *liber* being represented by the letters FC (cortical fibres), and the elements of the *suber* by the letters ES, the laticiferous vessels by the letters VL, and the herbaceous layer by the letters EC, the epidermis, EP, bristling with hairs, forming the external surface of the trunk. The medullary rays are plainly enough observable on the horizontal edge; they commence with the pith, and stop with that part of the wood which belongs to the

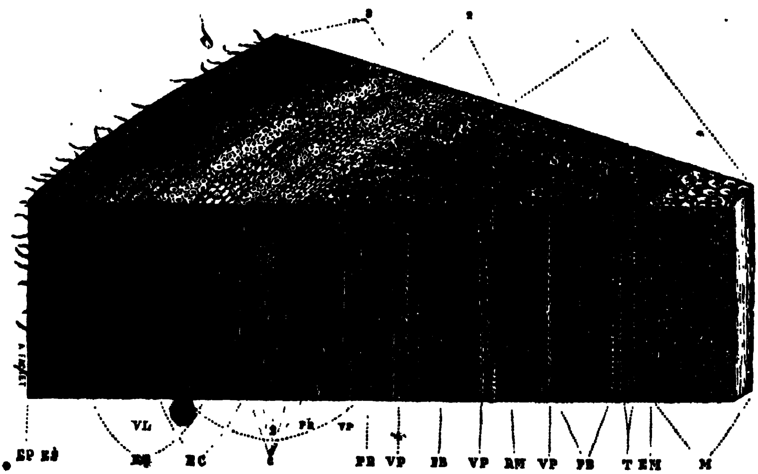


Fig. 51.—Transverse section of the trunk of the Maple.

second year's growth, as indicated in the vertical section by the letters RM.

Having reviewed all the constituting elements belonging to the trunks of forest trees with membranous leaves, we have now to speak of the structure of the stems of *evergreen trees*. Evergreen trees (*Pines, Firs*) are at once easily distinguished from the trees we have been considering by the structure of their wood, which is exclusively formed of large fibres, without any appearance of thick vessels. These woody fibres (Fig. 52) present besides the singular peculiarity of exhibiting on each of their lateral faces—namely, those which look towards the medullary rays—a row of dots or punctations, each

surrounded with a very remarkable cavity (*alveola*). The wood is traversed by *resiniferous ducts*, which are a kind of interstice in which the resin produced by the peculiar cells surrounding it is deposited and accumulates. Fig. 53 represents the transverse section of the stem of Fir-tree. We see that evergreen trees, like forest trees, present a central medullary canal, concentric woody layers, and cortical layers. But the wood-vessels have no existence in these stems, and the medullary rays are scarcely visible. The stem thus formed is said to be *exogenous*, from εξω, "without," and γεννaω, "I produce." All indigenous trees, and a vast number of our smaller shrubs and plants, have this form of stem.

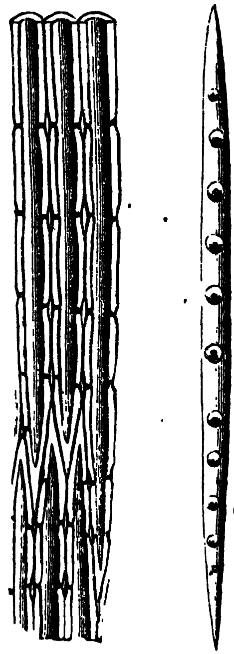


Fig. 52.—Woody fibre of the Fir-tree.

Fig. 53.—Transverse section of the trunk of a Fir-tree.

The general appearance of palm-trees is very different from that of our indigenous trees,—their long and drawn out stem (Lat.

stipa), perceptibly equal in thickness from the base to the summit, and completely bare, that is, not divided by boughs and branches, making them like some tall column surmounted with a thick tuft of leaves. What is the interior structure of this *stipa?* To give an idea of its formation, we must first understand that the growth of the *Palm-tree* differs from that of any group of trees we have hitherto considered. *Palm-trees* do not, like our evergreen and forest trees, increase their growth by concentric layers, deposited between the wood and the bark. The interior structure, therefore, must show arrangements very different from those we have been describing. Here there is no single central canal destined to hold the pith, no concentric layers distinctly separating the pith, the wood, and the bark; no medullary rays diverging from the centre to the circumference. If we cut the stem of a *Palm* across, we shall immediately see that it differs as much from the trunk of our trees in its inmost organisation as it does in its outward appearance. We look

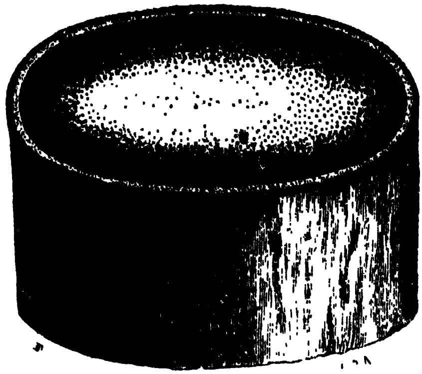


Fig. 54.—Section of the stem of a Palm.

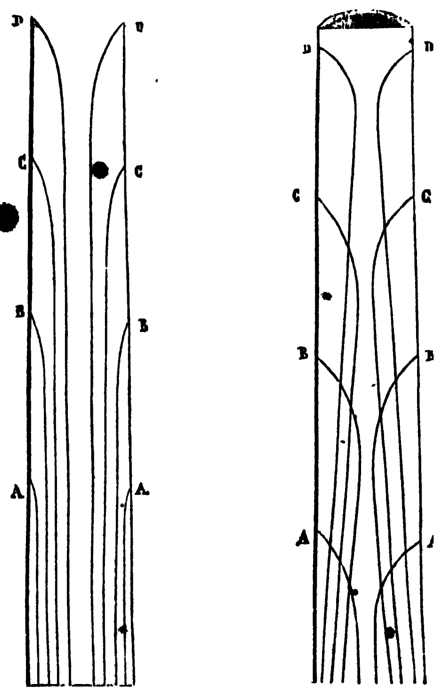


Fig. 55.—Theoretic figure showing the internal structure of the Palm.

in vain for the central pith, the concentric zones, the radiating lines, which so plainly characterise the wood of our indigenous trees. We should see, on a groundwork of palish colour, little spots of a deeper tint, formed by a more solid tissue. These little rounded or half-moon shaped spots are more numerous, more crowded, higher coloured, and in general larger towards the circumference of the stem than they are in the central part. This stem is called *Endogenous*, from *ενδον*, "within," and *γενναω*, "I produce." This stem, therefore, appears at first sight formed of two descriptions of tissue, one rather soft and pulpy, forming the bulk, so to speak, the other very solid, forming little islets in the interior of the former.

Microscopic examination has shown us that the first of these tissues is exclusively formed of cells, and may be compared to the pith of our indigenous trees. It is traversed also by vascular bundles or very tough fibres, the tortuous course of which may be traced theoretically by the help of Fig. 55, in which letters A, B, C, D represent the different interlacings of these fillets in the middle of the pith. The fibrous bundles which traverse the stem of the Palm and other trees belonging to the same natural group, present arrangements which are very interesting to understand. The anatomical structure of each of them does not appear to be alike through their whole length; it seems to become more simple the farther they are distant from the point where they leave the stem to pass into the leaves. In this higher part, at the end of its course, the fibrous bundle of which we speak is invested with the characteristic structure of the stems of our indigenous trees, including the medullary sheath; presenting, in fact, tracheæ, punctated and striated vessels of a greater or less size, ligneous fibres, and other peculiarities of indigenous stems.

The *Tree ferns* of warm climates approach in their appearance much nearer to *Palms* than to our indigenous trees. Their slender trunks, simple and branchless, and of nearly equal thickness from the base to the summit, support at a great height a tuft of leaves. Nevertheless, *Ferns* differ much from *Palms* in their internal structure. Round an abundant pith voluminous vascular bundles are drawn out, showing in the transverse section of the stem a winding form, more or less irregular and hieroglyphic, and grouped

in circles towards the circumference of the trunk. This is shown in Fig. 56, representing the horizontal section of the stem of a Tree Fern.

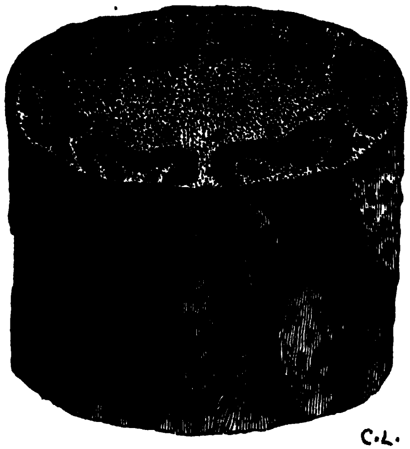


Fig. 56.—Section of the stem of a Tree Fern.

The reed-like bundles traverse the stem of the Tree Fern from top to bottom, presenting a dark edge, formed of very tough fibres, impregnated with a dark brown colour, containing cellular tissue and a few vessels of different sorts. Among these vessels we shall particularly notice some prismatic tubes, which show on each of their faces horizontal clefts very close to each other, and at equal distances, called *scalariform vessels.* Fig. 57 shows the structure and relative arrangement of the *scalariform* vessels in the trunk of a Fern-tree. These vessels are represented under the microscope. "Here," says Mr. Dresser, "the woody matter contained in the stalks of some leaves is transmitted into the stem, retaining the same disposition it did in the leaf stalks, in which case it surrounds the central cellular axis (Fig. 56); and the cellular apex of the stem grows and develops new leaves, the new portion of the stem being formed at the summit. Hence plants with this form of stem are said to be *acrogenous,* from *ακρο*, a "summit," and *γεννάω*, "produce," or summit growers. All ferns have stems of this form.

Fig. 57.—Scaleform vessels of the Fern-tree.

Although the Tree Fern has no close resemblance to the stem of either exogenous or endogenous plants, it seems to be more closely allied to the latter. Thus the rind or bark consists of layers of cellular tissue only, marked by the cicatrices of leaves or fronds, showing that its leaves are produced at the summit only.

Fig. 58.—Pollard Willows in blossom.

Of Buds.

We have studied the tortuous and deformed roots, and denuded trunks of trees; before considering the branches, the boughs, the leaves, and the flowers which decorate them, we pause at the organ from which emanate all these elements. We speak of the *bud*, which hides under its delicate green envelope the source of these brilliant ornaments of nature of which every year witnesses the birth and death. The bud is, in fact, the cradle of the young plant. This organ alone is capable of reproducing a new individual, and the horticulturist is familiar with many wonderful multiplications of species through its means. In ordinary circumstances, however, the bud is not intended to be separated from the mother plant: its function is to nourish, strengthen, and increase

in growth until it becomes an organ concurrent with the others in the life of the plant.

The bud may therefore be considered as a fundamental element in the plant, which, without it, would soon perish. It is the bud which year by year repairs the losses, supplies the flowers, the leaves, the branches which have disappeared. Through its means the plant increases in growth. Through it, its existence is prolonged. The bud is the true *renovator* of the vegetable world. It may be said, in fact, that a plant is all bud; there is scarcely any part that does not produce them; the roots, the leaves, the flowers even, may accidentally give birth to buds, for nature never loses sight of the phenomena essential to organic life—namely, the production of new beings.

Buds are of two kinds, namely, buds which produce leaves and branches, and buds which contain at once leaves and flowers.

The leaf bud is a scaly coneform organ placed on the axis of a leaf —in fact, a rudimentary leaf or branch, so to speak, formed as the growing season is about to close: it is, therefore, rather the cradle in which the leaf is to be nursed in the coming spring, than the parts of the leaf itself in a rudimentary condition. The growing point is composed of cellular tissue possessing special powers of vitality and growth, and in direct communication with the horizontal system of the pith of the stem.

The arrangements of the scales of buds are very various: the scales being rudimentary leaves, the arrangements of scales are also the arrangements of leaves. Some of their forms are familiar to us. There are no vascular structures within the point of the bud itself, but spiral vessels and woody fibre approach near to the base of the cone.

The flower-bud, on the other hand, is a stationary growing focus surrounded by rudimentary leaves, the growing point of which has become quasi-paralysed, and has no power of elongating itself; it is, in short, a stunted branch, from which the power of elongating itself by growth has been withdrawn, for it is well known that a stagnation of the juices is favourable to the production of flower-buds.

It is then necessary to avoid confounding the leaf-bud with the flower-buds, which contain only the flower ready to burst, to

astonish with its beauty and disappear. A rose or pink bud only encloses the flowering petals ready to open; while the *leaf-bud*, in its serried and complex mass, includes all the elements necessary to the production of a young plant, and as we shall see, it suffices to produce a new individual.

Buds are the first age and the earliest form of the vegetable axis; they occupy the summit of the axis, viz., the arm-pit or

Fig. [illegible] Bud of the Ash.

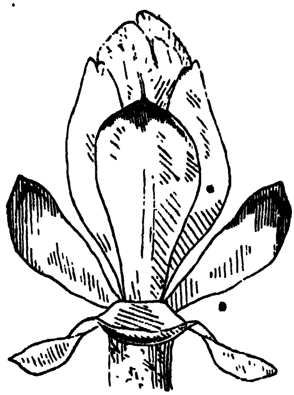


Fig. 61.—Evolving leaf-bud of Horse Chestnut.

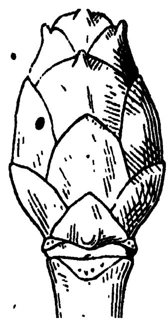


Fig. 60. Bud of the Horse Chestnut.

axil which they are destined to prolong. In the case of herbaceous plants in general, and with a great many trees of equinoxial countries, whose vegetation, so to speak, is increasing, the buds are *naked*, that is to say, all the young leaves resemble each other, and give out true leaves as they enlarge. But in countries where the winter, more or less vigorous, would destroy the delicate organs, the external leaves which cover the others are subjected to modifications which transform them into protecting organs. They are changed into *scaly* coriaceous membranes, frequently furnished on the interior with an abundant down of a thick hair, or with a coating of resinous juice, insoluble in water, and preserving considerable warmth. Under this shelter the rudiments of the young plant are so effectually swaddled up, so to speak, as to be thoroughly protected from the external air. Experiment proves that where the buds are detached from the tree, and the wound covered over with a varnish, they have remained for a long time under water without experiencing the least change.

The scales are modified leaves then, but it is not always the same part of the leaf which constitutes them. Nature employs divers processes for transforming a leaf into a scale. Again, between the scales of a *bud* and the leaf which they enclose, we frequently find a series of intermediate forms which throw considerable light on the metamorphoses of which the leaf is the seat when it passes

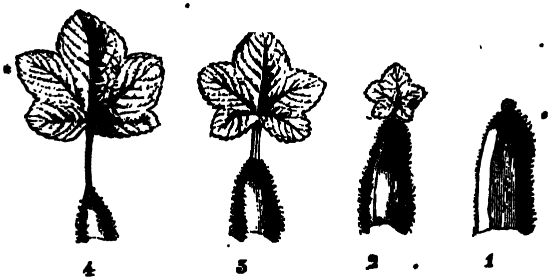


Fig. 62.—Gradual transformation of the leaves of the Currant (*Ribes*) into scales and leaves.

Fig. 63.—Bud of the Birch.

insensibly from one state to the other. Fig. 62, which represents the Currant leaf (*Ribes*) gradually passing from the leaf to the scaly state, shows sufficiently the transition from the one organ to the other, to render any further detail unnecessary.

The leaves are not always disposed in the same manner upon the bud, whether we consider them in their isolated state, or in the position they occupy in reference to the others. The mode of foliation sometimes becomes a characteristic very useful to the forester when he wishes to acquaint himself with the constitution of the trees during winter.

Let us consider each leaf independent of the others, and behold the different situations that the leaf may assume towards the interior of the bud. It may be folded up transversely in such a manner that the upper part rests over the lower, as in the Tulip-tree (*Luriodendron tulipifera*), Fig. 64. It may fold in its length in such a manner that one half of the leaf may lie over the other half, as in the Almond-tree (*Amygdalis sinensis*), Fig. 65. It may be folded several times in fan-shape, as in the graceful Birch-tree (Fig. 63); rolled round

Fig. 64.—Leaf-bud of the Tulip-tree.

Fig. 65.—Leaf-bud of the Almond.

Fig. 66.—Leaf-bud of the Poplar.

Fig. 67.—Leaf-bud of the Indian Shot.

itself, as it were, as in the Indian Shot (*Canna Indica*), Fig. 67; rounded on both edges, which reflect each other outwardly, as in the Dock-weed (*Rumex*), Fig. 72, or inwardly, as in the Poplar (*Populus alba*), Fig. 66.

We need not enter into more minute details on this subject. Figs. 68, 69, and 70, which represent vertical sections of the Sage

Fig. 68.—Transverse leaf of Sage bud.

Fig. 69.—Bud of Iris.

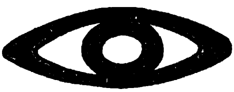


Fig. 70.—Section of a bud of Lilac.

(*Silvia officinalis*), Lilac (*Syringa vulgaris*), and the well-known Iris, will suffice to prove the mutual connection of the young leaves in certain vegetables, while they are yet shut up in the bud.

In most trees of temperate regions the buds make their appearance in spring, stopping at an early stage of their development, and only elongating themselves in the following spring. They ramify slowly, and it is only once a year that branches are produced. Nevertheless, in the case of the Peach-tree and the Vine, two generations of branches are produced. The cause of this is, that their scaly buds have remained stationary during the autumn and winter of the preceding year, have elongated themselves in the spring and given birth at the axils of their leaves to buds, which in place of remaining stationary, and developing themselves only at the commencement of the approaching season, grow without interruption, and produce new branches. French horticulturists have given the name of prompt-buds to these shoots. Branches which, on the other hand, only carry scale buds, and develop themselves the year after, are called *dormant* buds.

We have spoken of normal buds, which are borne on the axils of the leaves, or which terminate the axis. There are others which present themselves without any order, and the exact spot where they present themselves cannot be foreseen. These are adventitious

buds: they present themselves on all parts of the vegetable, now upon the stem, the leaves, the flowers, and the roots. The root of the Sumac, or Stag's-horn-tree of Virginia (*Rhus Cotinus*), for example; of the Dutch Poplar or Pollard Willow (*Salix Alba*); of the common Acacia, and many others, run horizontally in the soil very near the surface, producing adventitious buds, which root themselves rapidly, and rapidly multiply the plant, so that in a few years they become a considerable nuisance.

The formation of adventitious buds is frequently produced by accidental irritation. The wheel of a cart, for instance, grazes the trunk; or the root of a tree is wounded by the passing ploughshare, and an adventitious bud results. If we cut down the head of a group of forest trees; the plants which, left to themselves, would have become stately trees, are transformed into stunted groups which cover themselves afterwards with branches, all of the same age and the same strength; they have been transformed from trees of stately growth to pollarded dwarfs. In the case of the Willow, this principle of adventititious budding has been largely utilised. Willows of enormous trunks, but short and deformed, surmounted by a thick tuft of branches, as in the engraving at the head of this chapter, are commonly known as pollards, and owe their singular appearance to the regular and periodical cutting to which they are subjected. In consequence of this mutilation, a great number of adventitious shoots are formed, which subsequently produce so many branches of like size. These branches are cut to make supports for young trees, for pea-sticks in horticultural districts, and as props for the vine in wine-producing countries. In Epping Forest, in the neighbourhood of London, it has been the custom from time immemorial to have annual sales of these cuttings, at which the neighbouring inhabitants are supplied with wood both for firing and horticultural purposes.

When the Poplar-tree of Italy (*Populus fastignatis*) reaches twenty-five or thirty years, it is cut down, when it forms planks of some value; but it is also pruned every five years, the result of pruning being numerous adventitious buds, which produce branches much used for fences and for fire-wood.

Buds are placed upon the stem at regulated intervals, where

they develop themselves in the form of branches, and extend the tree, nourishment being carried through them to every leaf and fibre. It is also one of their peculiarities that, without injury to these organs, they may be separated from the parent plant and placed upon another, (which, so to speak, becomes its nurse.) Horticulturists profit by this circumstance to produce some of their finest flowers and fruits. This process, known to gardeners as budding or grafting, is practised in many different ways, but in all the principle is the same; the bud without any of the wood is carefully removed from the parent tree and applied to a corresponding cut in the nursing one, covering the wound so as to keep out the air. Fig. 71 shows the manner in which the cushion graft is performed; B represents the bud after it has been removed from the parent branch; A the nursing stem in which an incision in the form of a T has been made to receive it; C the graft secured in its place by means of wool or cotton thread, wound lightly, but closely round both. The bud continues to grow on its new nurse, and in course of time it forms a branch or head of a tree producing the same flowers and fruit for which the parent may have been celebrated. We need not enlarge here on the importance of this principle; it is applied most successfully in horticulture, where some delicate species of fruit or flowers is produced on a stem destitute of the vigour necessary to nourish and bring it to maturity.

Fig. 71.—Budding or cushion grafting.

The leaf-bud is thus a coneform organ placed on the axis of a leaf, in short, a rudimentary leaf or branch formed as the growing season is closing, and is the *nidus* in which the leaf will be formed in the coming spring, rather than parts of a leaf in a rudimentary condition. The central growing point (Fig. 60) is composed of cellular tissue possessing special powers of vitality and growth, and closely connected with the pith of the stem. From this point

all the future leaves have their development, and it is, in all probability, the organ whereby the circulation of the sap is effected after the winter's repose. This growing point has a certain analogy with the embryo in the seed, inasmuch as both tend to growth and reproduction; but they differ in this, that the leaf-bud needs no fertilisation for its development, and propagates the individual as well as the species, while the embryo imperatively needs fertilisation, and continues the species only.

Fig. 72.—Dockweed.

Fig. 73 —Italian or Stone Pine.

Boughs and Branches.

The branch is formed by the development of the bud, and this bud, as we have said, is the axil of the leaf.

The branch being only a secondary stem emanating from the

principal trunk, necessarily presents the same modifications of form, of structure, and of disposition of the leaf, which we observe in the trunk, properly so called; but the resemblance between the stem and its branches is not always complete; thus

Fig. 74.—Branch of Butcher's Broom (*Ruscus aculeatus*).

in the Butcher's Broom (*Ruscus aculeatus*), Fig. 74, the branches are short, and at their enlargement take so immediately the form of leaves, that the early botanists considered them to be such. But an attentive observer will not be deceived if he considers that these flattened organs with their foliaceous appearances bear at

their axils *scales* which are the true leaves, and carry flowers which are the exclusive characteristics of branches.

In some plants the branches expand considerably, but in most others they remain slender; their terminal bud abortive, they become pointed and hardened at the extremities; in short, they are changed into spines as in the Hawthorn (*Cratægas oxycantha*).

A modification extremely curious and interesting in the form

Fig. 75.—Subterranean roots of Potato.

and consistence of branches occurs in the Potato (*Solanum tuberosum*), Fig. 75, which is developed under ground. The subterranean part of the stem is not green, and the leaves, if we can call them so,

are only small rudimentary scales, at whose axils the branches, which extend themselves more or less horizontally, develop themselves, and are charged with abortive leaves. These branches, which are thin and slender at their origin, swell at their extremities, are filled with a green pulverulent matter, and finally become the tuber, which we recognise as the potato. In short, if we examine a potato, we see that it is covered at intervals with eyes, or scales. At the axils of these scales a bud is found; every one knows that these buds, when the potato is stored in dark cellars, push out long slender shoots at the return of spring. These are their true branches or stems. The fact that the parts here described are really portions of the stem, is curiously proved by the following instance recorded in the *Gardener's Chronicle*, vol. ii. p. 85. A potato plant had grown underneath an inverted flower-pot in a dark cellar, where it had formed itself into a perfect miniature potato plant. Being only surrounded by air, it had thrown out its branches, and meeting with no resistance, it had grown with the same regularity as an ordinary plant would have done above ground. The set, or old tuber, was shrivelled up, and formed a wrinkled knob, out of which grew many branches and branchlets. Of the latter, some had become thickened at the point, resembling young potatoes; others, having no power of extending themselves, had swelled close to the parent tuber. All wore covered scales, the rudiments of leaves. At first sight the plant appeared as if it had been unable to form roots, but a more minute inspection showed that they were really beginning to form here and there in many places upon the surface of the branches.

There is a great difference between *tubers*—between the *Potato* and the *Dahlia*, for instance. The tubercule of the Dahlia may be called a true root; it has no vital *node*, or joint. On the other hand, the stem of the potato bears many of these vital knots.

The length and direction of the branches, as compared with the parent stem, are extremely varied, and this variety tends to give to each plant its special appearance, its peculiar physiognomy. If the lower, and consequently first formed branches, continue to extend themselves in the same proportion, and the upper ones are shorter as they approach the summit, the form of the tree is conical or pyramidal, as in the Firs (Fig. 76). If the central branches

extend beyond the lower ones, the form is round or oval, as is the

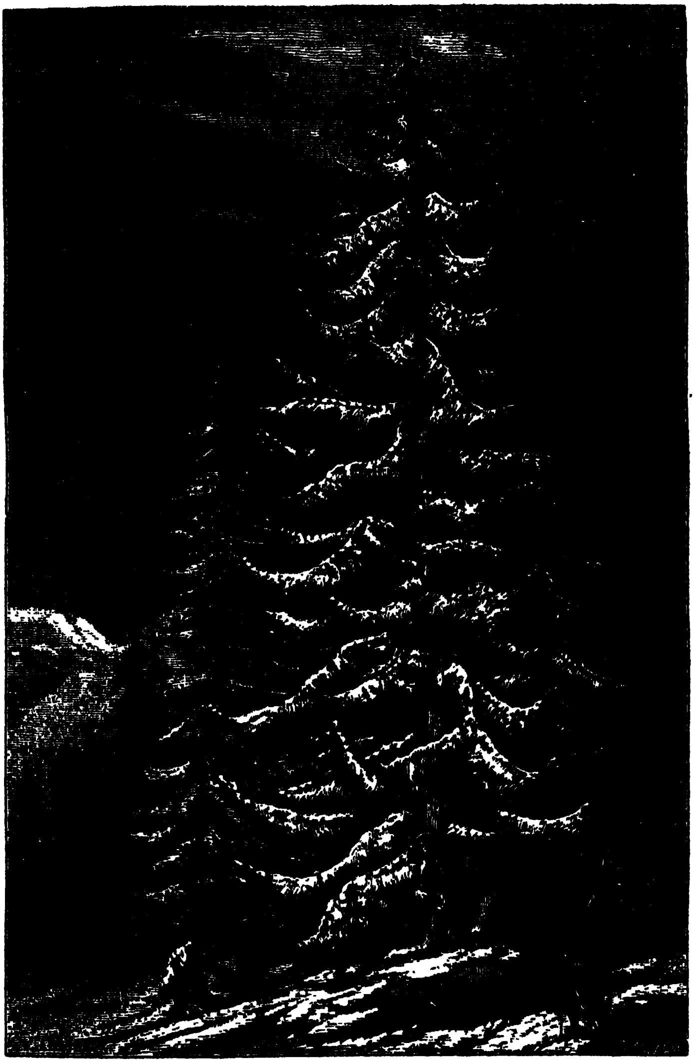


Fig. 76.—Spruce Fir (*Abies*).

case with the Horse Chestnut (*Æsculus Hypocastanum*), Fig. 77.

If the upper branches take a fuller development, as in the Italian Pine, Fig. 73, the summit of the tree expands in an umbrella form, and has been aptly compared to the spreading of volcanic scoria, expanding over the mouth of a crater, before it descends again

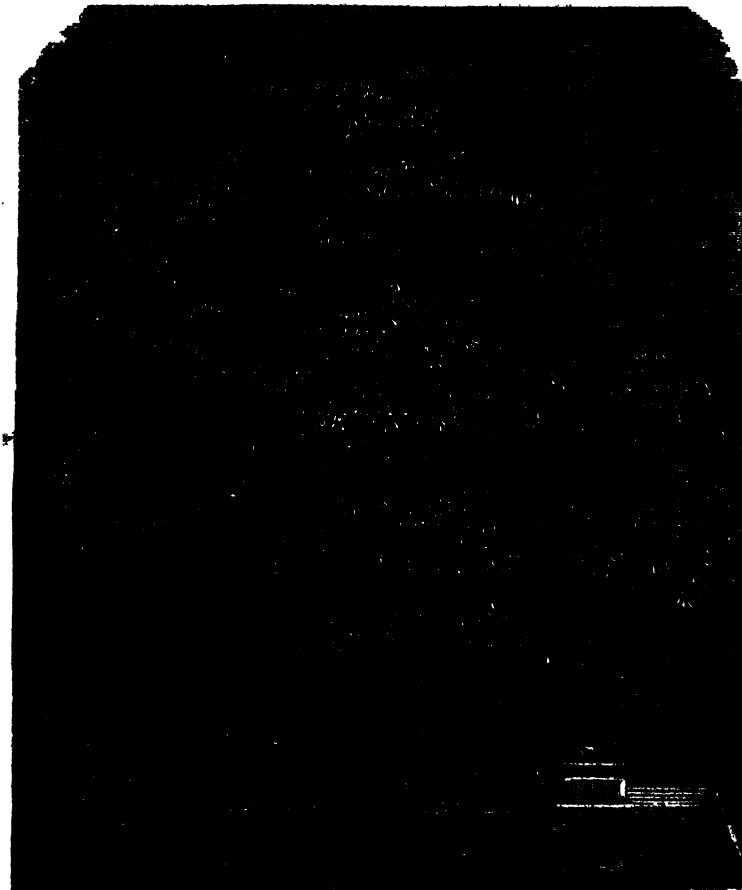


Fig. 77.—Horse Chestnut Tree.

to the earth. In all these instances the direction of the branch is decided by the manner in which the bud is inserted in the stem, and the direction and growth of the branch give its particular appearance to the tree. Branches issue from the stem at all

imaginable angles, sometimes at right angles, sometimes at angles

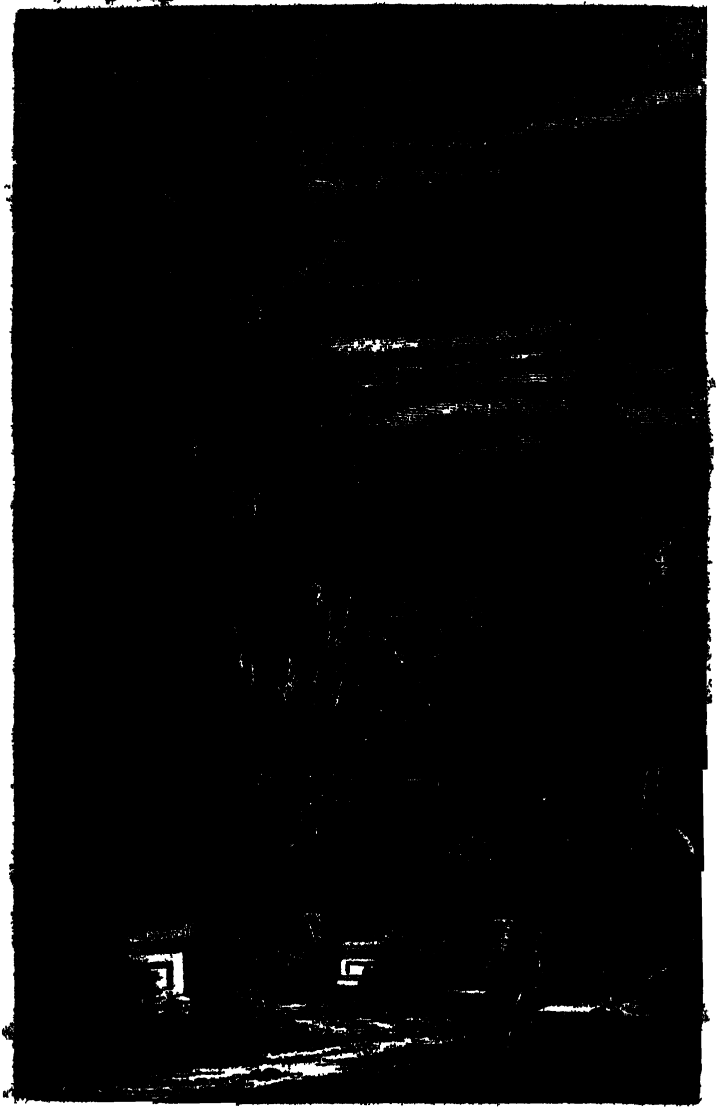


Fig 78 —The Cypress.

so acute as to seem at a little distance to rise with the bole of the

tree. The tapering branches of the funereal Cypress (*Cupressus*), as compared with a kind of dome formed by the branches of the Oak (*Quercus*), or the Cedar, give us some idea of the contrast which the two kinds of ramifications present. The Lombardy Poplar (*Populus fastigiata*), carries the contrast still further.

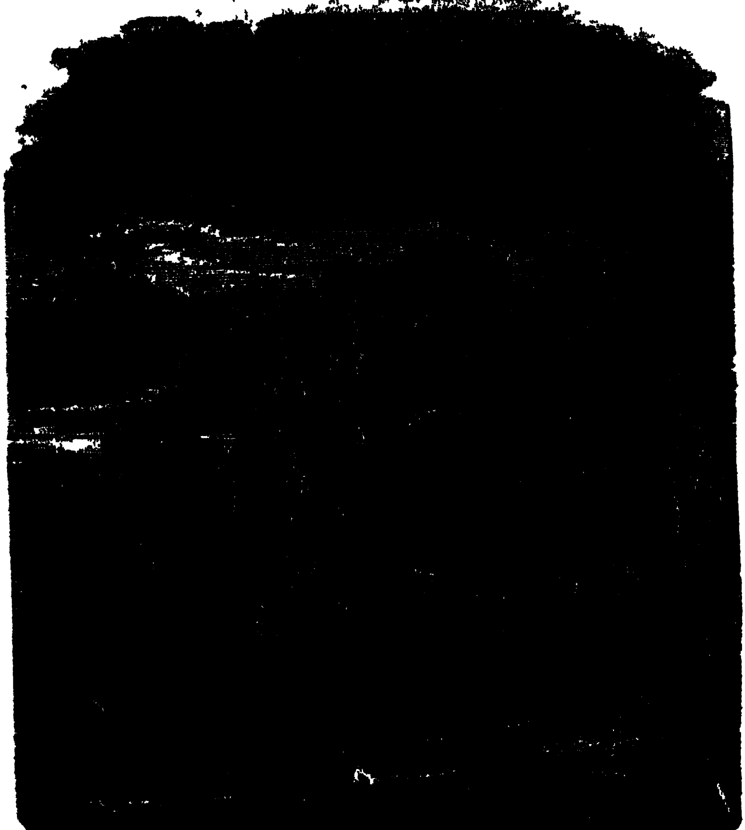


Fig. [illegible].—Weeping Willow.

The aspect of certain [illegible] trees places in bold relief the influence which [illegible] in which the [illegible] exercise upon the ramifications of the branches and the form of the tree.

In some trees the branches take a direction which seems inverse to the usual habit of trees. In place of rising towards the skies,

the branches appear to incline towards the earth with a drooping aspect. The Weeping Willow, represented in Fig. 79, presents

Fig. 80.—The Sophora of Japan.

a striking and well-known example of this habit of growth. The

long slender branches of this elegant tree fall by their own weight. But the habit is not confined to this tree. The ash and other trees are capable of being trained to it, and gardeners avail themselves largely of the habit, planting the banks of water basins, ponds, and brooks with the one, and forming shady places on lawns by means of the others. The Willow is at once elegant and sad in its aspect.

The branches of the Sophora of Japan (*Sophora Japonica*), or the Weeping Sophora, resemble the Weeping Willow in many respects, but they possess a certain rigidity at their extremities, which gives a tendency to resume the upward direction (Fig. 50).

We have said that a branch may be considered as a secondary stem, emanating from the principal one, from which it draws its

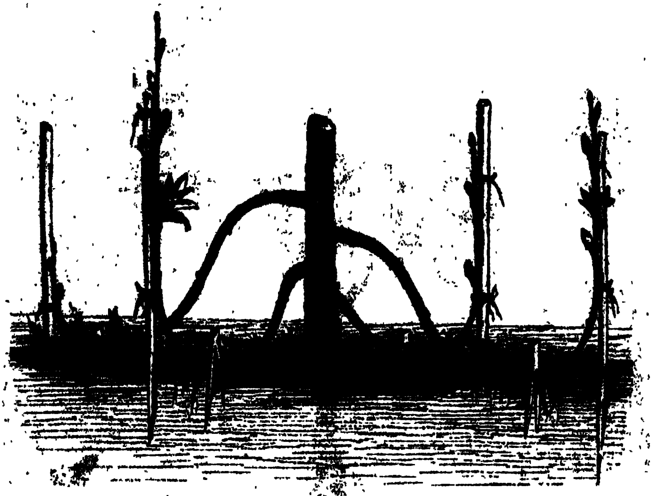


Fig. 51.—Propagation of layers.

nourishment. But if we give this secondary stem or branch another source of nourishment, it may be separated from the principal axis which carries it, and become a free and distinct individual of the same species. Upon this natural fact has been founded the process of *layering*, or root-grafting, well known in horticulture; bending a flexible branch towards the humid soil prepared for the purpose, the gardener maintains it in its position by

pegging down, as represented in Fig. 81, until it has thrown out roots. These roots being developed, it contains within itself all the elements of life. The branch may be separated from the stem, from which it no longer requires support. This process is known

Fig. 82 —Approach grafting by elevation.

as *grafting by inclination*. But every branch which it is desired to layer may neither be within reach of the soil nor sufficiently flexible to bend to the extent requisite. In such cases the soil must be raised to the branch. To effect this, vases or flower-pots

of various forms are employed, which are filled with earth, and maintained at the necessary height, the branch being placed in it traversing the vase in contact with the soil, as in Fig. 82. The soil being maintained in a humid state, the portion of the branch in contact with it is not slow to push forth its adventitious roots, which are soon present in sufficient numbers. In due time the branches may be separated from the parent stem, and transplanted elsewhere. This is called *layering by approach*.

Propagating by *slips* or *cuttings* differs from layering only in this, that the part of the plant employed in the process of multiplication is detached at once from the parent plant, and completely abandoned to the powers of nature. Cut a branch even of considerable size from a willow or poplar; give it a clean sloping cut across a joint or node, and bury it in humid soil, it will immediately push out adventitious roots, and soon begin to grow a new and independent willow or poplar. But all plants will not so readily accommodate themselves to this easy mode of multiplication. There are some plants which will not *take*, to use the consecrated term, without the aid of many complicated artifices; there are even some which resist all means known of propagation by slips; in short, the slip often finds itself subject to these alternatives—to die of inanition, for want of sufficient moisture, or to rot from overmuch liquid. The problem for the operator to solve, in order to favour the production of roots, is to establish a proper equilibrium between the aqueous losses to which the slip will submit, and the quantity of water which it absorbs; and to do so is not without its difficulties. But this is not the place to explain the processes by which these operations are successfully performed. We must content ourselves with remarking that the process is not confined to slips or cuttings of branches, as cited above. Cuttings may be made from rhizomes, from leaves, and even from parts of a leaf. But this last process is only employed for certain exotic plants; the inhabitants of our hot-houses which never bear fruit, and scarcely throw out branches.

Layers and slips are not the only operations in which branches are employed for the purpose of multiplication. There is another, the most important of all in garden operations, namely, *grafting*, of which we have already said a few words in connection with the

bud. Its object is to attach one vegetable to another, which is to

Fig 83.—Subjects for approach grafting

Fig. 84.—Approach grafting.

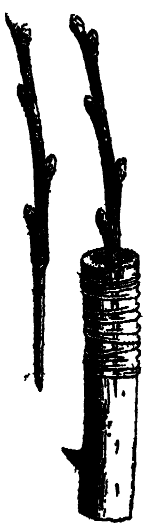
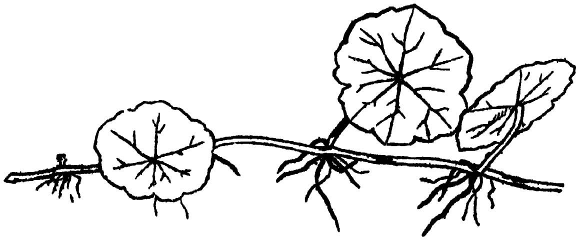


Fig. 85.—Cleft grafting.

sustain and furnish matter for its sustenance; to nurse it, in short. We sometimes see in forests certain trees, particularly the Hornbeam, in which a branch of one is firmly united to a neighbouring tree of the same species. This process, which in this case is a natural occurrence, is practised artificially to a great extent in gardening. The operator cuts a corresponding slice of bark from two trees, brings the two equal places into contact, and lashes them firmly together with cord, which is again covered with some sort of clay to keep the wound moist until a junction has taken place. This is *approach* grafting. Fig. 83 shows the manner of preparing the

two subjects intended for approach grafting. Fig. 84 exhibits two subjects firmly attached by means of ligatures.

In *cleft grafting* the trunk of a tree is cut through horizontally, and a vertical cleft is made in its centre some inches deep. Into this cleft the branch of a graft with several buds, and cut to the shape of the cleft, is inserted, which is closely in contact with the sides of the cleft. The cleft is then covered with mortar of some kind, and bound firmly together by means of cord. In Fig 85 we have these successive operations represented. Cleft grafting is operated successfully both on the trunks and roots of trees. By its means the horticulturist changes with advantage the products of trees of the same species, making the head bear fruit and flowers other than those belonging to the principal stem. In fact, they restore the vigour and sweetness of youth to a tree already aged and exhausted.



Prostrate creeping stem of Marsh Pennywort (*Hydrocotyle vulgaris*).

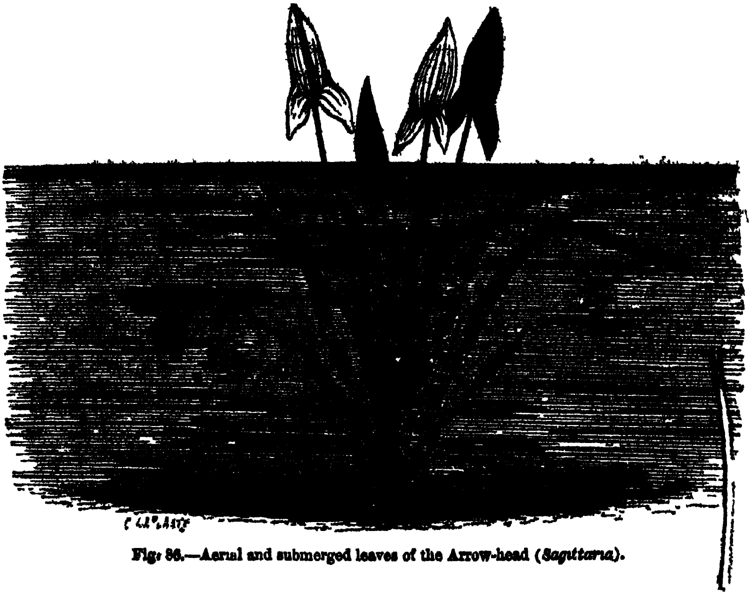


Fig. 86.—Aerial and submerged leaves of the Arrow-head (*Sagittaria*).

Of Leaves.

We have considered buds, which enclose in their green envelope the promises of spring. At the hour marked by awakening nature this cradle of the leafy organs will open itself step by step, and in a short time the gardens, the fields, and the woods will be clothed with a dazzling down of verdure.

The season of the renaissance of leaves is that which exercises the softest influence on the human soul, when the new vegetation begins to decorate the fields, and gives to the boughs and branches, long denuded by the hoar-frost, that cloud of vernal green so vivid and dazzling which brings with it that delicious impression which no animated beings can deny themselves. The reviving verdure is the forerunner of fine days, the first adornments of the fields announcing a brilliant *cortège* of flowers, a plentiful tribute of savoury fruits. Renovated nature offers at once to the eyes and the mind a most seducing picture, and what pleasure do we not

enjoy in the shade and shelter of the forest in the burning days of summer.

If the leaves have not the dazzling and variegated colours of the flowers of our fields or parterres, their green surface and variegated shades serve to repose the eye and preserve the sight. The movement of the leaves as they gracefully wave to every breath of wind, serves also to animate the landscape, and gives it a kind of existence.

But the functions of the leaves are not limited to mere ornament and shade. Nature, as we shall see, assigns to them infinitely more important offices, both to surrounding nature and to the tree of which they form a part. They purify the surrounding atmosphere, restoring it to its normal condition, rendering it healthy and salubrious when vitiated by the breath of animals. The Creator has in this, as in all His works, united decorative elegance and beauty of form with direct and immediate utility.

Leaves are borne upon the stem and branch, and nothing is more varied than the forms they assume. In *Sagittaria*, Fig. 87, they resemble an arrow or spear-head, whence its name. In the Juniper bush (*Juniperus communis*), Fig. 88, its spines are like so many needles. Others have false leaves, as in certain of the *Gladiolus*, which issue from a sheath like the *Iris*. Leaves in their turn affect the form of a disk, as in the *Nasturtium*, Fig. 89; or the form of a spatula in the Daisy (*Scabiosa atropurpurea*), Fig. 90.

Some leaves have forms so strange that botanists have been puzzled to describe them. For example, in *Nepenthes distillatoria*, Fig. 91, the leaves terminate in a most singular manner; forming a sort of urn or vase, surmounted by a cover, which opens and shuts as occasion requires. This vessel is suspended at the extremity of a thread-like appendage to a winged petiole, which would seem to be altogether unfit to support it. In a recent work we find the following facts recorded in reference to the leaves of the *Nepenthes distillatoria*. An officer of marines writes as follows:—"Three days after my arrival at Madagascar, I lost myself during a short excursion into the interior, and was overtaken with an excessive lassitude, accompanied with a devouring thirst. After a long walk I was on the point of yielding to despair, when I perceived close to me, suspended to leaves, some small vases, somewhat like

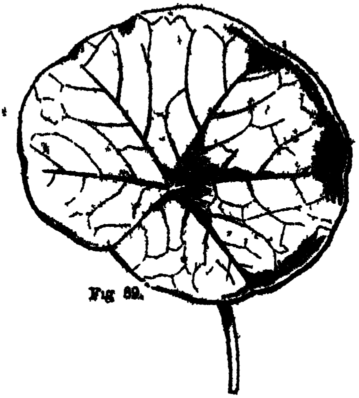


Fig 89.

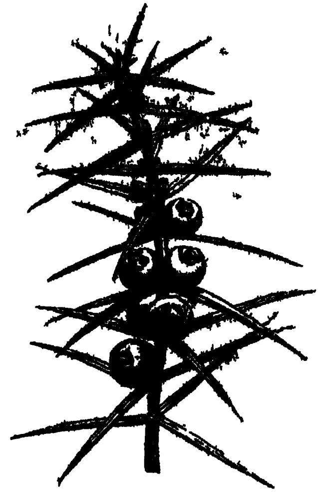


Fig 88.

Fig 91

Fig. 90.

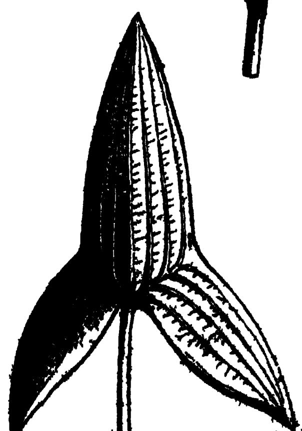


Fig. 87.

Fig. 87.—Arrow-head. Fig. 88.—Juniper. Fig. 89.—Nasturtium. Fig. 90.—Daisy.
Fig. 91.—Nepenthes. Fig. 92.—Catchfly.

those used on board to preserve fresh water. "I began to think I was under one of those hallucinations by which the sick are visited in fever when the refreshing draught seems to fly from their parched lips. I approached, however, with some hesitation, threw a rapid glance at the pitchers: judge of my happiness when I found them filled with a pure and transparent liquid. The draught I partook gave me the best idea I have realised of the nectar served at the table of the gods."

To pursue our subject, however. In the *Sarracenias* a number of the leaves are long and funnel-shaped, somewhat like a long horn or trumpet, as in Fig. 93; while in the Catchfly (*Dionæa*), Fig. 92, the leaves are terminated by two rounded plates or leaves furnished with hairs on their outer edge. When touched these leaves close upon their victim, and become, as it were, a charnel house when thus re-united.

Fig. 93.—Leaves and stem of Sarracenia.

Among the many species of plants which have been described, there are scarcely two whose leaves can be said to be perfectly alike. "These contrasts surprise the traveller," says Auguste de St. Hillaire, "when, in traversing equinoctial countries, he finds himself surrounded by thousands of forms which have among them all only one trait of resemblance—their elegance and grace,—when he sees the delicate foliage of the *Mimosa*, so sensitive to the touch, hanging over the gigantic leaf of the *Scitaminaceæ*, and the *ferns* with their thousands of finely cut leaves growing upon the trunk of the *Eugenia*, and mingling with *Bromeliaceæ* and *Tillandsias*, with their rigid and inflexible leaves."

"But more than this, we do not find in nature any two leaves

exactly alike. Sometimes the same plant maintains leaves having less resemblance to each other than those of two different species. The Paper Mulberry (*Broussonetia*), Fig. 94, has at the same time heart-shaped and lobed leaves. In the garden *Valerian* the lower leaves are entire, and those at the summit are deeply notched. In the *Ranunculus aquatilis*, Fig. 95, the leaves, which vegetate in the

Fig. 94.—Branch of the Paper Mulberry (*Broussonetia papyrifera*).

water, are divided into thread-like expansions, so narrow that they seem to be leaves reduced to their nervures, or skeleton, while those leaves which grow in the air are entire, and disk-like in form, and more or less notched. When the common Arrow-head (*Sagittaria*) grows in brooks, its submerged leaves form long ribbons; when they grow on the banks of great ponds or tanks, the emerged leaves resemble those of the Arrow-heads, Fig. 86.

There is not less diversity in their length and breadth, than in their form. While some leaves are only half a line in length,

Fig. 95.—Ranunculus aquatilis.

others attain the dimensions of five or six yards. Nor is their size always proportioned to the thickness of the stem which carries them. The leaves of a small plant, the Dock-leaf (*Rumex*), would cover many hundred times the space occupied by the fascicled leaves of the Larch, an imposing mountain tree; and there is a thousand times less vegetable matter in the leaf of the Fir-tree or Cedar than in that of the Plantain, or Banana-tree.

Fig. 96. Sessile leaves of the Flax plant.

The leaf usually consists of two parts—a stalk, or *petiole*, and the blade, or *lamina*. The petiole connects the leaf with the branch or stem, and is composed of a bundle of unexpanded fibres covered by an epidermis. When the petiole fails, as in the common Flax (*Linum*), Fig. 96, the leaf is said to be *sessile*. In such cases the leaves often partially

or entirely surround the stem, when they are said to be *amplexical* or *semiamplexical*. The leaf is *simple* when the limb consists of one piece either quite entire or variously indented, cleft or divided on the edge; and compound when it consists of one or more leaflets, each of which is jointed to the common petiole by intermediate little petioles, sometimes very short, and said to be *petiolated*. The leaf of the Lime-tree (*Tilia*), Fig. 97, is simple; that of the Robinia, or False Accacia, Fig. 98, is compound.

It happens sometimes that the petiole is branching and bears petioles of the second or third order, upon which are inserted *petiolules* with their folioles. This occurs in *Gleditschia tricanthus*, Fig. 99, a highly ornamental group of trees, with branching thorns in some of the species. When the division of leaves is carried further, the term decompound is made use of; the Hemlock (*Conium maculatum*), is said to be supra-decompound. The limb of the leaf is often continued all round, and sufficiently large to embrace it, as we see in the Box-tree, the Iris, and some other plants. The edge of the limb of the leaf is generally more or less serrated; according to the form and depth of these inequalities round the margin, the leaf is said to be *dentate*, *crenate*, *serrate*, *lobed*, and *cloven*.

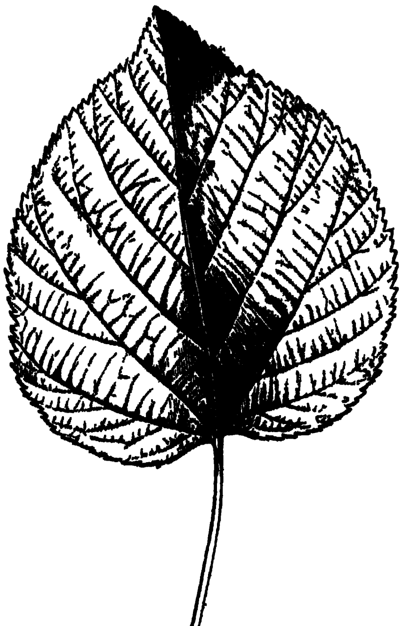


Fig. 97.—Leaf of the Lime-tree.

Leaves are dentate when the edge is intersected with acute pointed teeth, as in the *Chestnut*, Fig. 100. Crenate when the margin presents *saillant* parts, as in the *Saxifrage*, Fig. 101. They are lobed when the leaf is more deeply indented, as in the *Gingko*, Fig. 102. They are cleft when their division embraces one half of

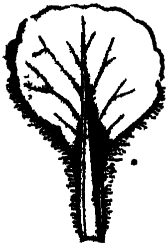


Fig. 101.

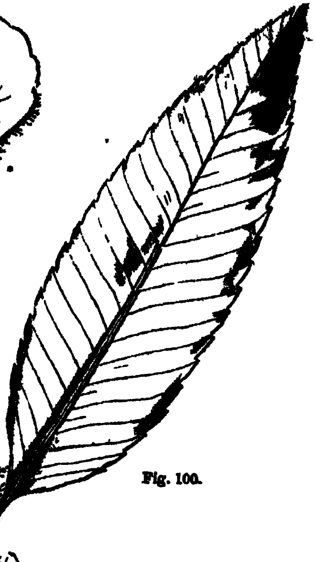


Fig. 100.

Fig. 99.

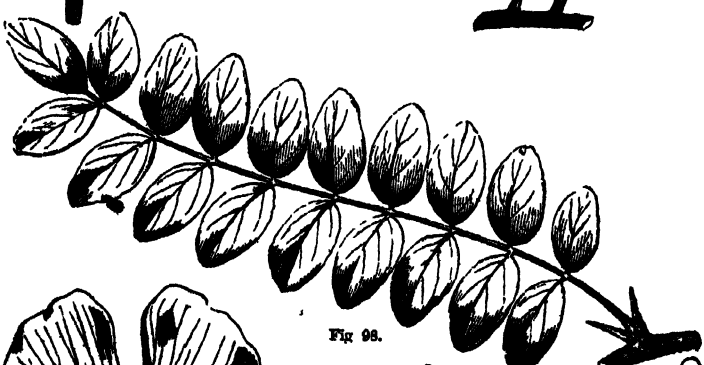


Fig 98.

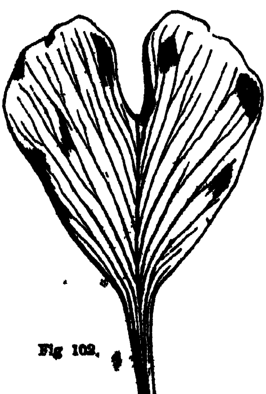


Fig 102.

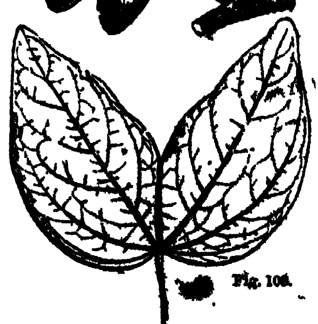


Fig. 103.

Fig. 98.—Leaf of Robinia. Fig. 99 —Leaf of Gleditschia. Fig. 100 —Chestnut Fig 101—Leaf of Saxifrage. Fig 102 —Leaf of Gingko. Fig 103 —Leaf of Bauhinia.

the leaf, as in the *Bauhinia*, Fig. 103, the leaf of which gives a very good idea of the cleft leaf. The leaf of Castor-oil tree (*Ricinis communis*), Fig. 104, is cleft in eight sections. Finally, leaves are partite when the separation penetrates nearly to the petiole, or reaches the centre of the limb, as in Fig. 105, a bipartite leaf, and again in Fig. 106, which represents the leaf of *Cannabis sativa*, the Hemp; as Fig. 107 does *Echinops sphærocephalus*, and as Fig. 108 does the leaf of *Scholymus hispanicus*, in which the divisions of the leaf are more numerous still

The leaf is, as we have said, a flattened organ having two surfaces, and border, the whole of which constitutes the *lamina*, or blade. The blade of every leaf is traversed by prominent lines or ridges, called veins, which are, however, more saillant on the lower face than on the upper. These are formed of woody tissues, spiral vessels and cellular tissues. They form the *nervure* of the leaf, and are retained in their positions, and the intervening space is filled up, by cellular tissue. The tissues of the veins are brought into closer proximity in the petiole, which is a small stem. Having passed into the stem, one part of the food of the plant enters the bark, while the other traverses the wood and penetrates to the medullary sheath at the centre of the stem. Every leaf is thus in communication with the stem, and not this only: it is, in fact, a prolongation of the pith, spiral vessels, and wood of the system. The disposition of the nervure, or veins, differs very little in the three principal types. In the Chestnut, whose leaf is represented in Fig. 100, the nervure runs from the base to the summit of the blade, sending out to the right and left a secondary set of veins parallel to each other, disposed like spray of a feather. In the Mallow (*Malva sylvestris*), Fig. 109, five principal nerves run from the base of the leaf to the apex, and radiate in the blade, like the foot of a web-footed bird. In the Iris, of which leaves are represented in Fig. 30, p. 40, a great number of delicate veins run from the base

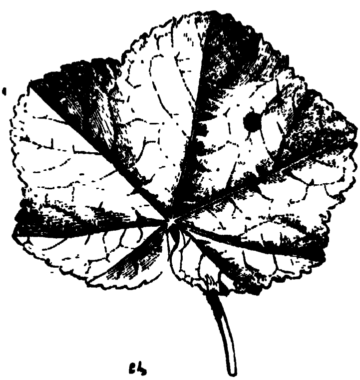


Fig. 109.—Leaf of the Marsh Mallow.

Fig. 107.

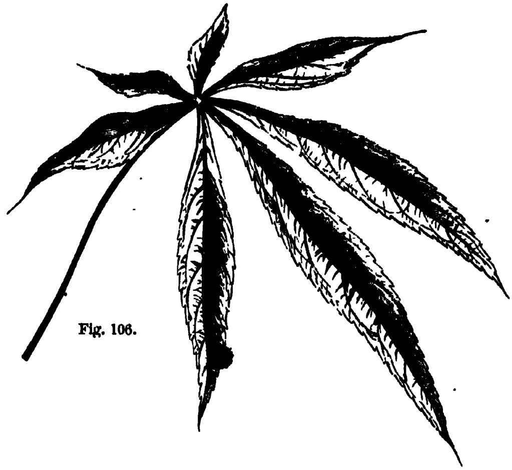


Fig. 106.

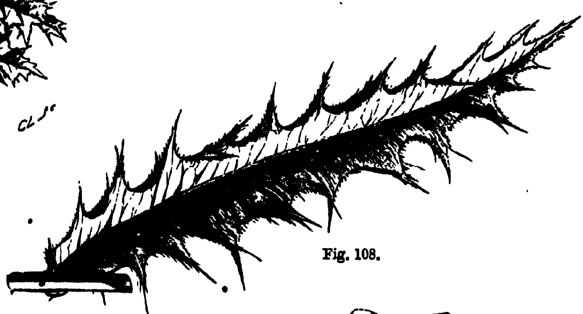


Fig. 108.

Fig. 105

Fig. 104.

Fig. 104.—Leaf of the Castor Oil Tree. Fig. 105.—A bipartite leaf. Fig. 106.—Leaf of the Hemp. Fig. 107.—Leaf of Echinops. Fig. 108.—Leaf of Scholymus.

of the leaf towards the summit, all being parallel to each other.

The petiole, sometimes long, sometimes short, and sometimes absent altogether, is often cylindrical, sometimes arched and inflated as in the Water Caltraps (*Trapa natans*), or compressed, as in the Birch-tree (*Carpinus betulus*), and many poplars, in which the surface is large, in place of being a continuation of the blade, it abuts upon it at right angles. In such cases the petiole gives little support to the leaf, but presents its two largest sides to the wind, which cause it to oscillate and tremble, producing the rushing sound which distinguishes the Aspen-tree (*Populus tremula*).

In some cases the petiole fails; the blade even may be defective; the leaf is then reduced to its petiole. But in such cases, in obedience to the laws of compensation, which intervene when any organ proves abortive, the neighbouring parts take a greater development; the petiole is enlarged and assumes a ribbon-like form, a sort of blade which was long taken for a leaf. It is distinguished by the position of its veins, and also by the fact that in place of being compressed in such a manner as to present the usual upper and under surface, it is set edgeways, and its two faces are lateral. This form of petiole is termed a *Phyllodium*, and is applied to so called leafless plants, where the petiole performs the functions of one. The *Acacia heterophylla*, Fig. 110, is full of instruction in this respect. We find in it all the intermediate steps between a perfect compound leaf and a *phyllode*. The petiole is there seen to flatten and enlarge in exact proportion as the leaf decreases; they bear leaflets at the earliest stage of their development, and have parallel veins, although occurring in exogenous plants. This transformation of the petiole, which is frequent in the Acacias of Australia, occurs also in many other plants, as in *Dionea muscipula*, Venus Fly-trap, in which the petioles extend laterally, and resemble true leaves; in the tendrils of the pea, and in some others belonging to the leguminous plants, as well as among the umbelliferous plants and the ranunculaceæ, the petiole grows longitudinally.

Leaves transform themselves into other organs with wonderful facility. It is, in fact, by modifications of the leaves that nature produces many essential organs in the life of plants. They are

changed into *scales*, a transformation of which we have an example in the Asparagus plant, Fig. 113; into tendrils, as we have already observed in the Pea, Fig. 111; and into spines, as in the Barberry (*Berberis*), Fig. 115, for spines would have become branches under other evolutions of the axillary leaf-bud.

Now what is the source of this disposition of leaves upon the stems and branches which carry them? Are they thrown at random upon the axes of the vegetable? The most superficial examination suffices to satisfy us that the leaves are always placed in

Fig. 110.—Acacia heterophylla.

the same manner and in a fixed order for every species of plant. In other words, that their relative distance and time are rigorously fixed by nature. A more profound examination leads to the conviction that this order is subject to certain laws, and may be expressed by an arithmetical formula. If we examine a branch of the Elm (Fig. 116), of the Willow, or the Cherry-tree, we observe at once that the leaves are all inserted at different heights. In

Fig. 114.

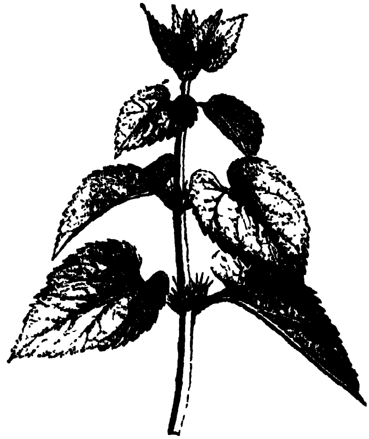


Fig. 112.

Fig. 111.

Fig. 113.

Fig. 111.—The Pea. Fig. 112.—The Nettle. Fig. 113.—Asparagus. Fig. 114.—Rose Laurel.

this case they are said to be *alternate*. In the Willow, the Nettle (*Urtica*), Fig. 112, on the contrary, the leaves are grouped in pairs all at the same height. These leaves are said to be *opposite*. In the Loose-strife (*Lysimachia vulgaris*), and the Rose Laurel, Fig. 114, three leaves are grouped at the same height round the stem. In this case, as also in cases where many leaves are grouped in the same manner, we say the leaves are *verticillate*.

Fig 115.—The Barberry.

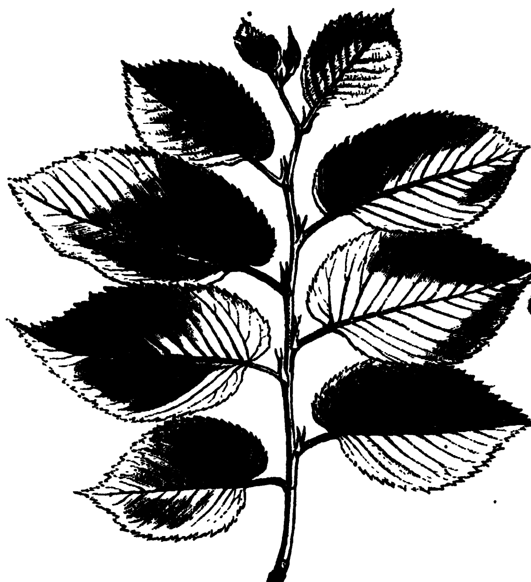


Fig. 116.—Branch of the Elm.

What gives to plants their peculiar physiognomy and appearance, is, that the elements which constitute the verticillate feature correspond with the intervals which separate the pair or group placed immediately above or below, and it may be added that the elements of a similar pair or verticille are always equidistant. To return, however, to the alternate leaves. Let us take a branch of the Peach or the Plum-tree, Fig. 117, and examine any leaf whatever. We shall find that higher up, the branch carries another leaf immediately above it, and that in the interval between these

two leaves there are four others diversely placed. All these leaves are placed upon the line of an ideal spiral, which commences in one leaf and terminates in the leaf on the line immediately above. The unit of the spiral may consist of one or more revolutions of the spiral round the axis. Fixing on any leaf and ascending the branch till the leaf immediately over it is found, by counting all the intermediate ones the number constituting the unit or cycle is arrived at. In the Peach and Plum-tree the cycle embraces five leaves, and the spiral goes twice round the branch. This is expressed in botanical language by the fractional formula $\frac{2}{5}$, the numerator indicating the number of turns the spiral makes on the cycle, the denominator the number of leaves which constitute the cycle, as in Fig. 118. In the Alder (*Alnus glutinosa*), Fig. 119, three leaves constitute the cycle; and the spiral only describing a single turn on the stem, the disposition of its leaves is represented by the fraction $\frac{1}{3}$, as exhibited in Fig. 120.

Fig. 117.—Branch of the Pe

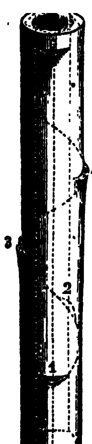


Fig. 118.—Insertion of Peach leaves.

In the Elm (*Ulnus*), as we have seen in Fig. 116, and in the Lime-tree, two leaves only constitute the cycle, in which case they are represented by the fraction $\frac{1}{2}$. Let us write these three fractions in a single line, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, and we find the fraction $\frac{2}{5}$ is the sum of the two first fractions. Let us add the

term of the $\frac{1}{3}$ and $\frac{2}{5}$, we obtain $\frac{3}{8}$. Do the same for $\frac{2}{5}$ and $\frac{3}{8}$, and we obtain $\frac{5}{13}$. In this manner the terms $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, $\frac{13}{34}$, are obtained. Singularly enough these fractional formulas express precisely the disposition of leaves which nature realises. The denominators of these fractions, in giving the leaves of each cycle, indicate at the same time the vertical lines following which the leaves are ranged.

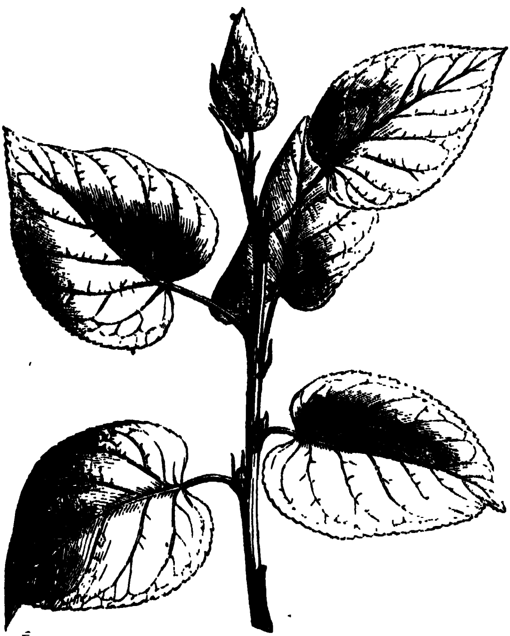


Fig. 119.—Branch of the Alder.

Thus in the Elm and in the Lime-tree, the leaves are disposed in two rows, and are said to be *distichous*, in which it agrees with the Ivy (*Hedera helix*), and the Yew (*Taxus banata*). In the Alder, the Meadow Saffron (*Colchicum autumnale*), the leaves are disposed in three rows, and said to be *tristichous*. In the Peach-tree, where the leaves are disposed in five rows, they are said to be *quincuncial*. "The distribution of leaves upon the branches," says De Candolle, "is in accord with their functions, which are almost exclusively determined by the action of the sun. In order that this action should exercise itself properly, it is necessary that the leaves be wide apart one from the other. We have seen that in all the systems by which the positions of the leaves are arranged, it results that the leaves which bear immediately above others are never covered. In cases the least favourable, the third only covers the first, and the fourth the second. In another case it is the

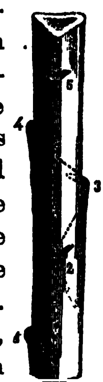


Fig. 120.—Insertion of leaves of the Alder.

sixth. Thus, in all these combinations, whether it be from the distance of the systems, or of the part, or from the size of the leaves, which diminish as they ascend, we soon find that all leaves are so arranged as to enjoy the free action of the solar light."

In most plants, when the leaves have accomplished their physiological functions, they fall, even in the year which witnesses their birth. But there are others which are not detached till the following year, while others still remain for many years attached to the stem. The leaves of most of the conifers, those of the Box (*Buxus*), the Holly (*Ilex*), of the Orange-trees (*Citrus*), do not shed them in the year in which they are developed, but are met by a continual growth of new leaves. These plants are never seen naked; they constitute the plants commonly known as evergreens. In the first of these states the plant is said to be *deciduous*, from *de*, down, and *cado*, I fall, when the leaves fall before the next spring. They are *marcescent*, from *marcesco*, withering, when they wither before falling, as in the Oak and Beech. They are *persistent*, from *persistens*, remaining, standing, when they remain longer than a year.

In some plants, as the Cactus, the leaves are shed almost as soon as they appear. These are said to be *caduccans*, from *cado*, I fall. The leaf thus dies like all created beings when the purpose for which it was created is accomplished. The immediate cause of death seems to be this: the cells of which it is composed have become encrusted with foreign matter, deposited during the processes of digestion and evaporation carried on by the organ, which then becomes incapable of further action.

On the subject of the distribution of evergreen trees, Auguste de St. Hilaire makes the following remarks:—"As we retire from the tropics, the number of evergreen trees goes on diminishing in rapid succession. At Porto Allegra, near latitude 30° south, I found in the coldest season that the trees nearly all changed their leaves. At San Francisco de Paula, near the Rio Grande, in 34°, nearly one-third of the ligneous vegetation had lost their leaves; and finally, at two degrees farther south, a tenth of the trees only preserved their foliage. At Montpellier, the fields in winter are not yet deprived of verdure; and Lisbon, Madeira, and Teneriffe

present a still more considerable number of trees always green. It must not be supposed, however, that in the tropics all the trees are evergreens. Even in the vast forests which occupy the Brazilian coast, and where vegetation is maintained in continual activity by its two principal agents, heat and moisture, there exist trees, such as some of the Begnoniaceæ, which lose every year, like our trees, all their leaves at once, but immediately after they are covered with flowers, and in a very short time these are succeeded by new foliage. I speak here of woods growing in equinoxial regions, where, as with us, rain and drought have no determinate period. In countries, on the other hand, where six months' continual rain is succeeded by uninterrupted dry weather, there are woods which every year remain for a considerable time destitute of verdure, and the traveller who traverses them is scorched by the ardent blaze of the equinoxial zone, while he has before his eyes the leafless image of European forests during winter. We have even seen this excessive drought continue during two years, and the trees remain for two years without their foliage."

But evergreen trees are only exceptional in the vegetable world. Most trees, shrubs, and herbaceous plants are without their leaves during one half the year. When the leaves have performed their functions, when the fruits have appeared, matured, and ripened, vegetation has entered into a new phase; the leaves lose their brilliant green and assume their autumnal tint, sometimes clothed, however, in colours of accidental, though transitory, brightness. The green, when it is persistent, is more grave and sober in its hue; it becomes brown in the Walnut, it takes a whitish tone in the Honeysuckle. The leaves of other plants, as the Ivy, the Sumach (*Rhus Cotinus*), the Dog-wood tree (*Cornus*), become clothed in a reddish tint; they become yellow in the Maple (*Acer campestre*), and many others of our forest trees. But whatever may be the variety of shades which leaves take in their decay, a certain air of sadness pervades these ornaments of our fields, which proclaims their approaching dissolution, and betrays the imminence of the cold season. Cold and humidity will soon arrest the sap and disorganise the petiole; the leaves, withered and deformed, will soon cumber the ground, to be blown hither and thither by the wind. It is the season of the fall of the leaf with all its

melancholy associations which the poets have depicted in so many well-known stanzas.

Nevertheless, leaves when separated from the vegetable which has given birth to and matured them, are not lost to the earth which receives them. Everything in nature has its use, and leaves have their uses also in the continuous circle of vegetable reproduction. The leaves which strewed the ground at the foot of the trees, or which have been disseminated by the autumn winds over the naked country, perish slowly upon the soil, where they are transformed into the *humus*, or vegetable mould, indispensable to the life of plants. Thus the *débris* of vegetables prepares for the coming and formation of a new vegetation. Death prepares for new life; the first and the last give their hands, so to speak, in vegetable nature, and form the mysterious circle of organic life which has neither beginning nor end.

But let us return to the general study of leaves. We have still to note a last and most important phenomena in the variety of eir functions. We speak of the spontaneous movements executed y leaves under many circumstances.

Leaves almost always assume the horizontal position. They have an upper surface turned towards the heavens, and a lower surface looking on the earth. This position is so natural, and hence so necessary, that leaves take it of themselves during day and night when from any accidental cause that position has been lost. If we place a plant in an apartment lighted by a single window, it is soon observed that all the leaves direct their upper surface towards the light. This is an experiment which our readers can readily repeat for themselves. But leaves perform other movements, equally remarkable, on which we must pause an instant. The study of these movements has been, as we shall see, the subject of some curious and interesting experiments.

Dutrochet, having placed a young pea in a chamber lighted on one side only, soon observed that the leaf inclined itself towards the light, and directed its petiole towards the heavens, or rather inclined it towards the dark part of the chamber. The tendril was now nearly straight; now curved and arched, presenting very irregular motions. Dutrochet placed certain fixed indicators both over the tendril and over the petiole, and at the insertion of the

two folioles. He was thus able to state what direction it took in retiring from the fixed indicators. He soon observed that the summit of the petiole described an ellipsoide curve in the air while the tendril which terminated it had various motions. He soon observed that the internode of this leaf participated in this movement of revolution, and that it was even the principal agent in it. The *merethale* or internode and the leaf then produced by their general movements a sort of cone, whose summit occupied the lower part of the metherale, and whose base was the curve described in the air by the summit of the petiole. The tendril, during the movement of revolution, constantly described its point towards the bottom of the chamber, thus shunning the light, turning itself when the movement of its revolution in leading its point near the window tended in the direction of the light.

This revolution was effected in a period varying with the temperature and the age of the leaf. It lasted from an hour to twenty minutes at a temperature of 24°; from seven to eleven hours when the temperature was lowered to 5° or 6°. The extent of the revolutions diminished in proportion as the temperature decreased. "What is the cause of this revolving movement?" asks Dutrochet. "It is not revealed to our eyes. It is some vital and internal exciting cause. Not only does the light contribute nothing towards the production of the movement, but it operates against it, and when unusually vivid it seems to stop it."

Dutrochet observed the movement of revolution in the tendril of the Bryone, and also in the cultivated Cucumber. In the Bryone the tendril moved in very varied directions, sometimes moving horizontally, sometimes upwards, sometimes downwards, and sometimes directing its points towards the heavens, then taking any curve whatever in order to take immediately a curve in the contrary direction. The tendrils of the cucumber moved like the hands of a watch placed on the dial plate, directing its points successively towards every point of the compass, sometimes to the right, sometimes to the left. But it defied all the sagacity, all the quick and deliberate observation of Dutrochet, to discover the slow and obscure movements of which we speak, or their origin.

The spontaneous movements which we have now to note in certain vegetables, are much more apparent. Let us speak first of

the movement of the plant known as the *Desmodium gyrans*, Fig. 121. This plant belongs to the family of Leguminaceæ. It was discovered in Bengal, in the neighbourhood of Daca, by an English lady, named Morison, whose devotion to natural history had led her to undertake the Indian voyage, and who died on one of her botanical excursions.

The leaves of the Desmodium are composed of three folioles. The terminal foliole is very large, and the laterals very small, but these last are almost always in motion. They execute little jerks somewhat analagous to the movements of the seconds of a watch. One of the folioles rises and the other descends at the same time, and with a corresponding force. When the first begins to descend, the other begins to rise. The large foliole moves also, inclining itself now to the right, now to the left, but by a continuous and very slow movement when compared with that of the lateral folioles. This singular mechanism endures throughout the life of the plant. It exercises itself day and night, through drought and humidity. The warmer and more humid is the day, the more lively are its movements. In India the plant has been known to make sixty jerks in the minute.

Fig. 121.– Desmodium gyrans.

This curious plant, which was introduced into Europe for the first time in 1777, is cultivated in the Museum of Natural History of Paris. The auditors of M. Brougmart's course of lectures have frequently had their attention directed to the strange phenomenon of which it is the subject. Its movements occur spontaneously and without any apparent cause. But there are movements in other plants which are produced by external causes. Such are those of the Catchfly and the Sensitive plant.

The *Dionæa muscipula*, Fig. 122, is originally from South America. Its leaves, which are spread out on the soil near the roots,

are composed of two parts—the one elongated, which may be considered as a sort of petiole, the other larger and broader and nearly circular, formed like two trap-nets, which are united at the base by a nervure, fashioned like a hinge, and furnished round the edge with rough hairy cils. In the upper surface these plates are furnished with certain small glands, whence exudes a viscous liquid which attracts the insects. If a fly lights on this singular apparatus, the trap raises itself quickly by means of its long hinge. They approach, and it closes, rapidly crossing its long cilia, and the insect is a prisoner. The efforts of the fly to escape, increases the irritability of the plant, whose fangs only open when the movements of the animal have ceased, with its life.

Fig. 122.—Dionæa muscipula.

Who that knows, who that has seen the Sensitive plant, *Mimosa sensitiva*, Fig. 123, has not also remarked on the strange sensibility of its leaves? The lightest touch suffices to make its folioles close upon their supports, the petiolar twigs upon the common petiole, and the common petiole upon the stem. If we cut with scissors the extreme end of one foliole, the others immediately approach in succession. De Candolle was in the habit of placing a drop of water upon one of the folioles of the Sensitive plant, applying it with so much delicacy as to excite no movement whatever. But

when he substituted for the water a drop of sulphuric acid, he observed that the folioles shrivelled up, the partial petioles as well as the common petiole was lowered, and gradually submitted to its influence, without the folioles situated below participating at all in the movement. This experiment shows very clearly that the irritation is not local, but communicates from circle to circle in the various elements of a leaf, and propagates itself from one leaf to another.

During the time that these movements are in operation, it will be observed that the limb of the foliole neither curves itself nor shrivels. In short, the contractile power resides at the point of

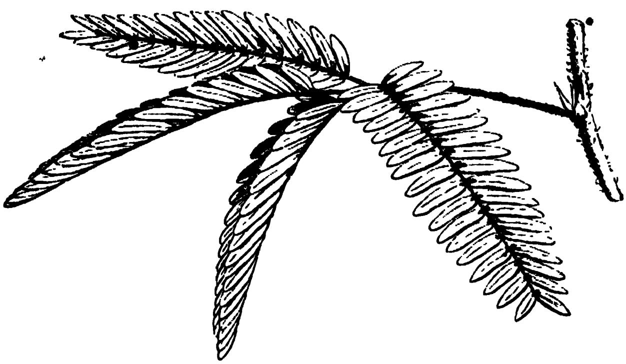


Fig. 123.—Branch of the Sensitive Plant.

insertion of the folioles upon the secondary petioles, these upon the common petiole, and these again upon the stem. These various points of insertion correspond to the very perceptible cylindrical cushions which during the season of rest swell below, while in the state of irritation they are distended above. The movement which we provoke in the case of the Sensitive plant manifests itself with much greater rapidity when irritated upon this cushion than in any other part of the plant.

We have remarked that the more vigorous the Sensitive plant is in its habit, the more susceptible is it; the higher the temperature, the more promptly does it respond to the touch. We may observe besides that the Sensitive plant can, up to a certain point, get accustomed to the movement. Desfontaines, carrying a Sensitive

plant in a carriage, observed that the plant closed its folioles, and all its leaves drooped as soon as the carriage began to roll over the pavement, but by degrees it seemed to recover from its fright, became habituated, so to speak, to the movements, its leaves resumed their erect position, and its folioles their full expansion. Desfontaines now caused the carriage to stop for a time. When it resumed its motion the plant responded by dropping its leaves as before, but after a time they expanded again, and so continued during the remainder of the journey. Shall we not say that here there is reflected impression and motive on the part of this singular plant? These phenomena of irritability under the influence of direct chemical or mechanical action, the plant repeats of itself during the night. The Sensitive plant closes its folioles when the obscurity of night sets in.

This habit of folding up its leaves during the night is not confined to the Sensitive plant exclusively; it appertains to other plants whose leaves occupy different positions during day and night. These are the plants to which Linnæus alludes when he writes of the *sleep of plants.* "But we must remark," says De Candolle, "that this term, borrowed from the animal kingdom, does not represent the same idea in both. In animals sleep indicates a flaccid drooping state of the members, of limpness in the articulations; in vegetables it indicates a changed state; but the nocturnal state maintains the same degree of rigidity and the same constancy as the diurnal position. We may break the sleeping leaf rather than maintain it in the position which belongs to it during the day."

It was in the Bird's-foot trefoil, the pretty *Trigonella ornithopodioides*, that Linnæus remarked for the first time the difference between the altitude of the leaves during the day and night. Scarcely had he made this remark when he came to the conclusion that this phenomenon would be found not to be confined to this single plant, but would be found general in vegetable life. From that time, every night Linnæus tore himself from sleep, and in the silence of nature studied the plants in his garden. At each step he discovered a new fact. Each natural fact, when put in evidence by a first observation, has been rapidly confirmed by crowds of facts quite analogous to the first, and Linnæus very soon satisfied himself that the change in the position of leaves during

the night was observable in a considerable number of vegetables, and that in the absence of light, plants quite changed their physiognomy, so that it became very difficult to recognise them from their bearing. He further states that it was the absence of light and not the nocturnal cold which was the principal cause of the phenomena, for plants in hot-houses closed themselves during the night just like those which were exposed in the open air. He recognised also that this difference is much less apparent in young plants than in more matured ones.

The illustrious Swedish botanist made many observations on the diversity of position that leaves affect during the night, and he has even attempted a classification of these differences. The most general idea which he sought to establish, was, that the positions differed according as the leaves were simple or compound. Linnæus thought that the object in these circumstances was to place the young shoots under shelter from nocturnal cold and from the effects of the air. It is among the composite leaves, in short, that the difference between the waking and sleeping is most clearly indicated.

The folioles of the Trefoil stand erect, curving in a longitudinal direction in such a manner as to form a sort of cavity or cradle. The folioles of the Melilotus are half erect, but divergent at their summits. In the Oxalis, Fig. 124, the folioles usually rest upon a common petiole, in such a manner as to turn their lower surfaces inwards, and show only their upper surfaces. In the Bladder Senna (*Colutea arborescens*) the folioles rise vertically in such a manner as to rest perpendicularly upon the common petiole, the upper surfaces turned towards each other. The Cassias have, on the contrary, the folioles depressed and folding back on the lower surfaces. The folioles of the Mimosa rest the length of their petioles in the direction of their summits in such a manner that the two extreme folioles are directed forward, folding back upon their upper surfaces, and the others falling upon the back of the folioles which range near the summit.

The leaves of the Orach root (*Atriplex hortensis*) fall back upon the young shoots and enclose them, as if to protect them from the effects of the atmosphere. The Chickweed closes its leaves during the night, and only opens them in the morning. The Evening

Primrose (*Œnothera*) has similar properties, and like the Trefoil forms during the night a sort of cradle for the reception of the leaves. On the contrary, the genus *Sida* and the *Lupinus* reverse their leaves. On the other hand, many of the Mallows roll their leaves into the form of a coronet. The Vetch, the Sweet Pea, the Broad Bean, rest their leaves during the night one against the other, and seem to sleep.

This strange sleep of plants vaguely recalls to us the sleep of animals. In its sleep the leaf seems, by its disposition, to approach the age of infancy. It folds itself up, nearly as it lay folded in the bud before it opened, when it slept the lethargic sleep of winter, sheltered under the robust and hardy scales, or shut up in its warm down. We may say that the plant seeks every night to resume the position which it occupied in its early days, just as the animal rolls itself up, lying as if it lay in its mother's bosom.

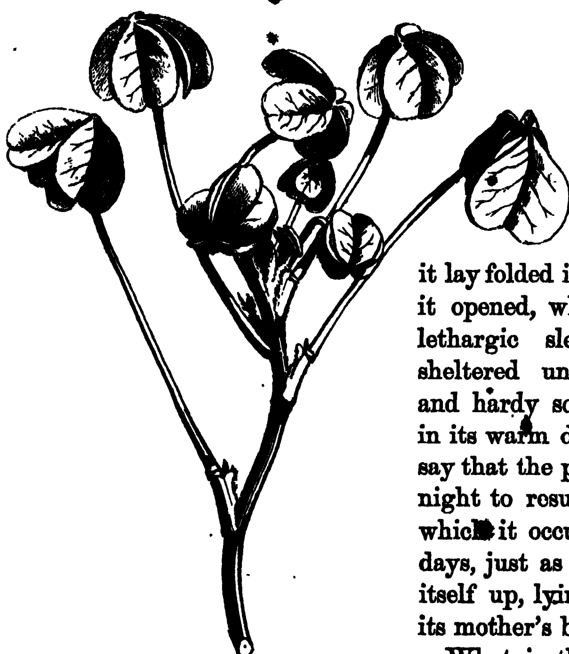


Fig. 124.—Closed leaves of Oxalis.

What is the cause of the phenomenon which we designate the *sleep of plants?* It occurs in all hygrometrical conditions of the atmosphere, and the hours during which it affects them is not influenced by any change of temperature. De Candolle supposed that the absence of light was the direct cause of the phenomenon. To assure himself of this, he subjected plants whose leaves are disposed to sleep, to the action of artificial light, furnished by two lamps which were, when united, equal to five-sixths of daylight. The results were very varied. "When I exposed the Sensitive

plants to the light during the night, and to the shade during the day," says De Candolle, "I observed that at first the plants opened and closed their leaves without any fixed rule, but after a few days they seemed to submit to their new position, and opened their leaves in the night, which was day to them, and closed them in the morning, which was their night. When exposed to a continuous light they had, as in their ordinary state, alternations of sleeping and waking; but each of the periods were shorter than ordinary. On the other hand, when exposed to continued obscurity, they still presented the alternations of sleeping and waking, but very irregularly."

De Candolle adds that he was unable to modify the sleep of two species of Oxalis either by light or darkness, or by light at other than the natural periods. We may conclude with him, from these facts, that the movements of sleeping and waking are connected with some disposition inherent in the vegetable, but which is thrown into special activity by the stimulating action of light, which acts with different intensity on different vegetables, so that the same amount of light produces different results in different species.

Having thus minutely studied the exterior character of leaves we shall endeavour to penetrate a little into their structure, and unveil the delicacy of their arrangements.

A cellular tissue, to which we give in this case the name of *parenchyma*, from the soft, pulpy, and closely approximating cells of which it is composed, and which have been aptly compared to a mass of soap bubbles pressing against each other, fills all the interstices of the leaves left by the spreading *nervures*. It is covered, consolidated as it were, and protected against all external influence by the *epidermis*, a covering which spreads itself like a protecting mantle over the whole surface of the plant. Let us submit this *parenchyma*, *nervure* and *epidermis*, to microscopical examination, first considering the leaves of those vegetables which live on the air.

If we pull to pieces with some care any leaf whatever, a fragment of transparent membrane without colour will be observed to detach itself from the leaf. If we place this moist shred upon a glass plate, and subject it to a magnifying glass, it will be found composed of large flattened cellules, having a contour, sometimes

rectilinear and figuring as a square, sometimes irregular and sinuous, as in Fig. 125. The granular contents of these cellules are neither very apparent nor very important, but we find in them betimes an aqueous liquid variously coloured. The cellular elements of this epidermous membrane are intimately united and pressed one against the other, in such a manner as to give it a certain solidity and power of resistance. The cells present an exterior wall in connection with the air, which is much thicker than the lateral or interior walls. Some of these cells are sometimes observed to be elongated, ramified, partitioned off, as it were, so as to constitute hairs or down of various forms.

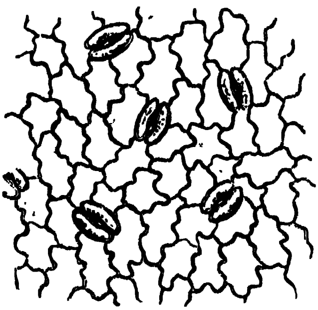


Fig. 125.—Structure of the epidermis of a leaf.

The epidermic membrane is not continuous or perfectly close. It presents, on the contrary, from space to space, small openings formed by the separation of two cells. These openings being elastic, and capable of expansion or compression, according to exterior circumstances, are intended to exhale the gaseous and vapoury products of perspiration in the plant, and also to absorb the gas and moisture of the atmosphere, the function of the cellular tissue of the epidermis being to transmit fluids in all directions. They bear the name of *stomates*, from the Greek word *στόμα*, "mouth." A stomates of *Cycas* under the microscope is seen in Fig. 126.

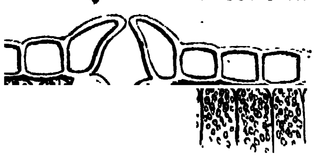


Fig. 126.—Stomates of a Cycas magnified.

The stomates are most abundant on the lower surface of leaves. Their number varies much according to the plant; and the smaller they are, the more numerous. In the Pink they present four thousand in the space of a square inch; the Iris twelve thousand, and the Lilac a hundred and twenty thousand. The epidermis which covers and protects the parenchyma of the leaf is itself covered with an extremely delicate pellucid membrane, whose structure is almost inappreciable, the discovery of which we owe to M. Adrien

Brongniart. It is termed the *cuticle*. It adheres closely to the epidermis, moulds itself exactly on this membrane, and even upon its hairs, to which it forms a sheath, much as the glove does to the finger, covering the epidermis, but presenting minute openings of great delicacy corresponding at all points with the *stomates*.

In the parenchyma of the leaves of the greater number of vegetables, two distinct regions, an upper and a lower, may be observed (Fig. 127). In the upper regions, one, two, or three rows of oblong cells may be traced perpendicularly to the surface of the leaf, and closely pressing one against the other, spread out, sometimes in such a manner as to leave between them many air-cells, which are generally found to correspond with a stomates. The lower bed is composed of irregular cellules, often branching out and touching each other only at the extreme points of their branchiæ, and leaving them numerous air-cells, which communicate one with another, forming a sort of spongeous tissue. Among these cells, many are situated immediately upon the epidermis of the lower surface, which is riddled with a much greater number of stomates than is the epidermis of the upper surface. It is these stomates with which the air-cells correspond.

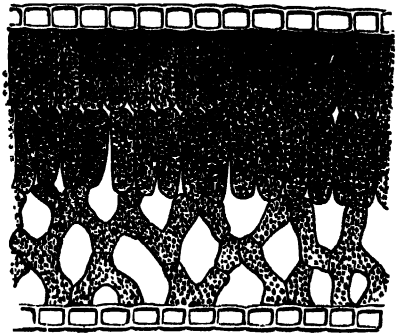


Fig. 127.—Transverse Section of a Leaf, showing the Structure of the Parenchyma.

These parenchymentous cellules, whose walls are always very thin, are filled with globules of the green vegetable fluid to which young plants and leaves owe their colour. This chlorophylle is found in great quantities and much denser in the upper zone, than in the lower and more spongy parenchyma. The aggregate of cells thus coloured by the chlorophylle give to the vegetable leaf that green and uniform tint which is its characteristic.

We have noted these peculiarities of organisation, and above all the existence of these intercellular *meatus* or air-cells,—cavities which communicate freely between them, and which are thrown in connection with the ambient medium by means of the stomatic

openings, so admirably organised for carrying out the vital phenomena of which it is the seat, phenomena which we shall study more minutely by-and-by.

We find in the *nervure* of the leaves, vessels of divers orders bound together by cellules of various forms, which constitute the fibrous part of this bundle. The structure of the nervure, which is most complex, becomes more simplified in proportion as it is divided and diminished in its dimensions.

If from plants with aerial leaves we pass to plants with leaves which float upon water, or whose natural position is to be submerged, we shall see the structure of these organs modifying themselves according to the medium in which nature has placed them. These curious modifications have been carefully studied in our own day by M. Adrien Brongniart.

The leaves of the Water Lily (*Nymphea*), which float upon the water, present, it is true, both epidermis and parenchyma, differing very slightly from those with aerial leaves, but the lower epidermis in contact with the water has no stomates. The submerged leaves of the *Pond Weed* are generally very thin and quite destitute of any epidermis, and consequently of stomates also. They are channelled with air-cells, which have no communication with each other, but are formed of polyhedrous or many-sided cellules, compressed and gorged with green fluid. These air-cells have no analogy with those of aerial leaves; they can only be considered as reservoirs of air furnished by the plant itself, and calculated, no doubt, to reduce its weight. They are floating apparatus, which seem to play a part analogous to the natatory vessels of the fish.

The *Ranunculus aquaticus* present at once, as we have seen, the aerial leaves which float on the surface of the water, and the much-divided leaves which are submerged. The aerial leaves, furnished with an epidermis provided with stomates, present a parenchyma whose structure scarcely differs from that of the aerial leaves already described. Aquatic leaves have no epidermis properly so called, but only greenish parenchymatous cellules pressing one against the other, constituting thus a parenchyma uniformly dense, hollowed here and there with isolated aeriform cavities, as in Fig. 128.

We cannot conclude our study of leaves without saying a few

words upon the *stipula*. These stipules are organs of only secondary importance, which accompany the leaves in certain plants. They are organised like leaves, but they are not true leaves. At an early period in the growth of certain plants, two small tumours appear, one at either side of the base of the leaf-stalk. As they are developed they become *stipula*, a blade. They appear later than the leaf, at whose base they are developed, but at some period of their existence they almost invariably enclose the leaf, being of quicker growth than the leaves. But their form and functions are altogether different, being small foliaceous organs with membraneous appendages, whose points of insertion are very various. In the Tulip-tree, Fig. 129, we observe two *stipules*,

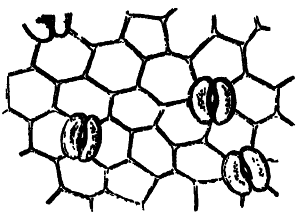


Fig. 128.—Cells of Aquatic Plants.

Fig. 129.—Stipula of Tulip-tree.

Fig. 130.—Branch of the Rose-tree.

placed the one on the right and the other on the left of the point of insertion of the leaf-stalk. In the Rose-bush, Fig. 130, the two stipules are attached to the petiole of the leaf. In the Hop-plant,

Fig. 131, the two stipules are on the same side of the stem, and belong to two different leaves, being so mingled together as to appear to form two double stipules. In the Buckwheat, Fig. 132, we see only a stipula placed between the leaf and the stem.

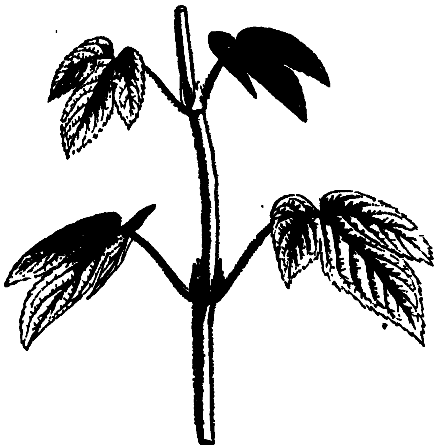


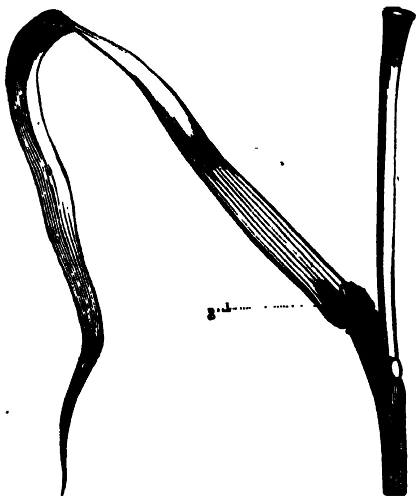
Fig. 131.—The Hop-plant.

The stipula appears, as we have said, after the leaf which accompanies it. Nevertheless, it often grows much more rapidly than the leaf, and in the bud they often completely cover these organs. They are probably intended in this case to shelter the young leaves. They are also very fugitive. Sometimes the stipules have neither this rapid development nor this fugitive character. They are then called *persistent.* It is probable that in their persistent character they are useful to the plant, either in sheltering its more delicate organs and feeding the buds, or in replacing the leaves when they are prematurely shed.

Fig. 132.—Buckwheat (*Fagopyrum*).

In the grasses (*Gramineæ*) there is a little membrane which appears to be a continuation of the inner lining of the petiole or sheath beyond the origin of the lamina of the leaf. It is called *ligula,* shoe latchet. As an example of ligula we give a vegetable furnished with the ligula leaf, the *Milium multiflorum,* Fig. 133, which represents a branch

of this plant. The ligula is represented by the letters L.g, at the base and internal face of the leaf, which is sheathed like all the grasses. Here the leaf-stalk or petiole has its origin in one of the nodes of the stem; while at L.g, the apex of the sheathing petiole, there is a small membrane which appears to be a continuation of the inner lining of the petiole beyond the origin of the lamina of the leaf. This is the collar, or *ligula*.



Fig[illegible]33.—Ligula of Millet-grass.

PHENOMENA OF THE LIFE OF PLANTS.

EXHALATION, RESPIRATION, CIRCULATION.

Having acquired some knowledge of the external arrangements and of the internal structure of the roots, stem, and leaves, we may now consider the essential phenomena in the life of plants, namely, vegetable physiology, in some of its most important points.

Vegetation presents in exhalation, respiration, and circulation of the sap in the interior of the tissues, three functions only secondary in their importance to reproduction.

Exhalation.

Exhalation in plants is performed by the leaves and branches. Plants exhale water or vapour by their leaves; it is retarded by the presence on the surface of the leaves of a coating of wax which gives them their greyish-blue glossy appearance, and it varies according as the epidermis is thick or thin.

The medium in which the plant is placed also greatly influences the function of exhalation. If the air is very dry, the exhalation is abundant and rapid. It is less active where the air is charged with humidity; it increases as the temperature rises; it is diminished during the night.

It is not alone by the stomates of the leaves, but also through means of the epidermic membrane itself, that exhalation takes place. The result of the perfect equilibrium which exists between the absorption of the roots and the foliaceous exhalation, is proof of a normal state of healthy vigour in the plant. If exhalation exceeds its absorbing powers the plant must fade.

It must be added, however, that at the same time that leaves transpire, they also reciprocate and absorb water by their own surface. This function of absorption does not appear to bear any proportion to the number of stomates, but seems to be more or less considerable according to the quantity of wax which covers their surface, absorption being most active where this coating is thin.

Respiration.

If we place an entire plant or a leafy branch in a balloon filled with gas which cannot be renewed, and leave the whole in darkness for some ten or fifteen hours, we may assure ourselves at the expiration of this time that the atmospheric air contained in the balloon is no longer of the same composition as before the experiment. Carbonic acid will be there in greater abundance, and the quantity of oxygen will be less. But if in place of leaving the plant in darkness we expose the apparatus to the influence of the sun's rays, the phenomena will be reversed; after a few hours the air in the balloon will have lost a noticeable quantity of its carbonic acid, and will be enriched in its oxygen.

In order to test this phenomena, let us fill a bell glass with water, to which has been previously added a considerable proportion of carbonic acid gas, and place in it a branch or an entire plant covered with leaves; expose the whole to the rays of the sun for some hours, as is represented in Fig. 134. The air, if analysed after the experiment, will be found to contain scarcely any carbonic acid, but it will contain a larger portion of oxygen than before the experiment. If a branch of a plant, with the roots fixed in soil, and consequently in its normal state of vegetation, is placed in a glass vessel, and by means of an air-pump a given quantity of air is caused to circulate round it, this air, which, before the experiment, contained from four to five ten-thousandth parts of carbonic acid, after the apparatus has been exposed to the influence of the sun's rays for a certain time will not be found to contain more than from one to two. If, on the contrary, the experiment is made during the night, it will be found that the quantity of carbonic acid would be increased, and at the expiration of a certain time

would have risen to eight ten-thousandth parts. These experiments, in which there is an interchange of gas between the plant and the atmosphere, exhibit the double phenomena of absorption and exhalation in plants; in fact there is *respiration*. But the respiration of plants is not always the same, like that of animals, in which carbonic acid gas, water, and vapour is exhaled without cessation either by day or night. Plants possess two modes of respiration: one diurnal, in which the leaves absorb the carbonic acid of the air, decompose this gas, and extract the oxygen whilst the carbon remains in their tissues; the other nocturnal, and the reverse, in which the plant absorbs the oxygen and extracts the

Fig. 134.—Respiration of plants exposed to light. Arrangement of the experiment.

Fig. 135.—Respiration of plants exposed to light. Result of the experiment.

carbonic acid; that is to say, they breathe in the same manner as animals do. The carbon which is used by plants during the day is indispensable to the perfect development of their organs and the consolidation of their tissues. By respiration plants live and grow.

It is necessary to remark here that it is only the green parts of vegetables which respire in the manner described; that is to say, by absorbing carbonic acid and disengaging oxygen under

the influence of light. The parts not coloured green, such as the wall fruit, seeds, red and yellow leaves, &c., always respire in one and the same manner: whether exposed to light or left in darkness, they always absorb the oxygen and disengage carbonic acid. They respire in the same manner as animals. If we consider that the green parts of the plant are far more numerous than those which are otherwise coloured,—that the clear light nights of hot countries may rather be said to diminish than to interrupt their respiration,—that the season of long days in northern countries is that of the greatest vegetative activity—we shall be led to the conclusion that the great mass of plants live more in light than in darkness, and consequently that their diurnal respiration greatly preponderates over their nocturnal. The diurnal respiration of plants, which pours into the air considerable quantities of oxygen gas, happily compensates for the effects of animal respiration, which produces carbonic acid gas, injurious to the life of man. Plants purify the air injured by the respiration of men and animals. If animals transform the oxygen of the air into carbonic acid, plants take this carbonic acid back again by their diurnal respiration. They fix the carbon in the depth of their tissues, and return oxygen to the air, in reparation.

Such is the admirable equilibrium which the Creator has established between animals and plants, such the beneficial communication which assures to the air its constant soundness, and maintains it in that state of purity which is indispensable to support the life of the living creatures which cover the globe.

We have now been speaking of the respiration of aerial plants. Water plants cannot respire by the same organic mechanism. In these the air circulating across the intercellular meatus of the leaves acts directly upon the pithy contents of the cells. The leaves of aquatic plants, which are destitute of epidermis, and are in general very slight, borrow air which the water holds in solution, in such a manner that, according to the ingenious remark of M. Brongniart, they respire in a manner analogous to that presented by fishes and other animals which breathe by gills.

Plants which live in perpetual darkness, and which consequently are always subject to nocturnal respiration, maintain certain modifications in their exterior aspect. In this anomalous condition

they lose a great part of their carbon, which passes into the state of carbonic acid, and they exhale large quantities of water: The result of these two phenomena is a decided elongation of the plant, a greater softness in its tissues, and the absence of green colouring.

The juices of plants kept constantly in the dark modify themselves in a sensible degree. Often acrid and bitter in their normal condition, they are rendered sweet and succulent under such modifications, and market gardeners turn these facts largely to their profit. They set Lettuce plants in artificial stations in order to make the hearts white, by binding them closely together and tying the leaves one against the other, to the exclusion of light. Sea Kale, which grows a wild, useless weed on the sea-shore, becomes a delicate dish under the gardener's care, aided by this principle of blanching.

Circulation.

The manner in which nourishing juices circulate in the interior of plants has long been the subject of discussion amongst botanists, and science is still far from being agreed on this important point of vegetable physiology. Limiting ourselves, however, to the consideration of dicotyledonous vegetation, such as our indigenous forest trees, we may enunciate the following simple facts on which all botanists are agreed.

Let us follow the juices of a dicotyledonous plant from the moment of their absorption by the root fibres. Let us see the course these liquids follow as they rise in the interior of the plant, and that which they take in order to descend again after having passed through the pervious tissues of the leaves, exposed to the chemical influence of the air; in other words, let us follow the progress of the sap both in its *ascending* and *descending* course. From the moment when the water which impregnates the earth has penetrated into the roots of a plant, and mingled its sap with the juices which are contained in the cells of the vegetable, it constitutes what botanists call the *sap*, a complex fluid, which, at certain periods in the life of a plant, circulates constantly through its tubes. What is the force which causes the water to penetrate into the roots, impels the sap into the

stem, and finally to its last ramification, namely, the leaves? What is the route which the sap follows in ascending? Does it traverse the pith, the bark, or the wood? or, finally, does it permeate through all three at the same time?

When a tree is cut down in spring it is easily seen that the sap flowing in it is then in the wood. If a plant is made to absorb coloured liquid, or if the branches are plunged into the same liquid, it is easily seen that it does not rise first either in the bark or pith. It is the wood or ligneous body through which it manifestly takes its passage. This passage is effectuated through all the ligneous elements, cells, fibres, and vessels. The anatomical construction of these vessels, their large number, their strength in the prostrate filiform and slender stems, which often attain a very considerable length, and which require to be traversed by a large quantity of sap in order to supply what is necessary for evaporation by the leaves,—all these general facts leave no doubt as to the part which the wood vessels play in the circulation of the sap. There is besides nothing easier than to ascertain directly the presence of sap in the interior of the wood. Such, then, we may conclude, is the true path followed by the ascending sap.

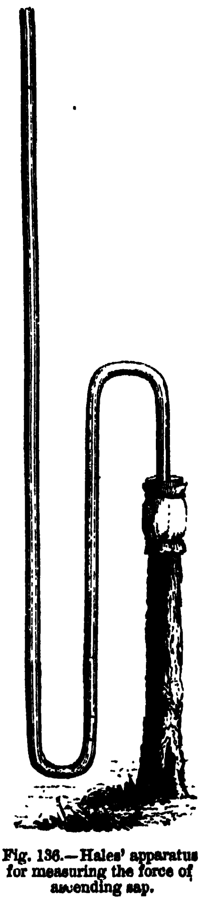


Fig. 136.—Hales' apparatus for measuring the force of ascending sap.

Dr. Hales, an English physiologist, to whom science is indebted for numerous experiments throwing light upon the movement of the nourishing juices in plants, was anxious to discover the force with which the sap rose in the stem. In order to ascertain this, he fastened a bent tube on the top of an ascending branch of a vine-stem in the spring; having carefully fixed the tube upon the transverse section of the vine-stock, the lower bend being filled with mercury. The flowing sap accumulated in the interior branches began little by little to move the mercury, till it rose to about forty inches in the tube (Fig. 136). The flow of sap then

was sufficiently powerful to move a column of mercury, in addition to the weight of the atmosphere, this height. Hales calculated from this that the force which impels the sap in the vine is five times as great as that which impels the blood through the large arteries of the horse. Having reached the leaves, the sap comes in contact with the air by the innumerable openings or *stomates* which communicate with the air-cells and hollow *meatus* in the substance of the parenchyma. The respiration of the plant, that is to say, the chemical action which the air exercises upon the liquids which supply the leaves, together with the exhalation of vapour which proceeds from the same organs, modifies the ascending sap in the same manner that air modifies the veinous blood in the sanguinary vessels and lungs of animals, changing it into arterial blood. Thus it is with the leaves in the phenomena of exhalation and respiration, of which they are the seat. In ascending, the sap changes its nature, and becomes transformed into a nourishing fluid.

We must now inquire what is the path which this new or descending sap takes after it has undergone this important modification. Everything tends to the belief that it circulates in the bark. Let us see what are the facts which justify this opinion. If a stem or branch is strongly bound in such a manner as to compress the bark, a cushion or excrescence is formed above the ligature, which continues to increase, and appears to proceed from the stoppage of the circulation, showing that the nutritious fluids come from above, for the parts beneath the ligature show no increase. The same phenomenon is produced upon the trunk of the tree when annular or spiral incisions are made all round it. Again, the trunks of trees round which creeping or twining plants wind themselves, demonstrate the same physiological fact in a very peculiar manner. Above the natural ligature produced by the pressure of the parasitic plant, a natural cushion is formed and a swelling produced by stopping the sap in its supposed descent through the bark.

In speaking of the structure of roots, we have enumerated the causes under the influences of which the sap ascends; the causes which determine its descent are, we must acknowledge, imperfectly known to us. It appears most probable that it is through the deep layers of the bark, especially through the net-like fibres of the *liber*, the

admirable structure of which we have before mentioned, that this sap takes its way. These fibres are very rich in a mucilaginous and albuminous matter. Some physiologists consider that there are additional vessels as principal and essential reservoirs for the elaborated sap, but it must be confessed that the subject is very obscure. The circulation of sap is in its most active state in spring time, when the plant is gorged with nutritive matter preserved in deposit during the winter. It is then full of liquid, and in some plants the juices flow from the slightest incision. In spring, according to the poetical expression consecrated by use, the vine and other plants bleed; but when the leaves are fully developed, the active evaporation which takes place on their surface impels the liquid to the extremities of the vegetable, whence it exhales in vapour; they will no longer bleed when wounded.

When the branches develop themselves and consolidate, the movement of the sap becomes slower; it is sometimes roused towards the end of summer, when, the spring having been premature, the materials which the plant has elaborated for the vegetation of the following year have been set to work before their time. After the fall of the leaf, and when the approach of winter lowers the temperature, the movement of the sap is stopped entirely; the tree arrives by little and little at a state of almost absolute repose: this is not death, but life, which awaits its reawakening.

It thus appears that all plants in a healthy state must be so situated, as to be able to absorb from the soil surrounding them the elementary bodies which constitute sap, namely, carbon, oxygen, hydrogen, and nitrogen, which are capable of forming a number of secondary combinations; as well as those which are necessary to the growth of certain families. The principal form in which these bodies are absorbed is, as water, carbonic acid, and ammonia.

Water is supplied to plants in the form of rain and vapour; according to Schleiden, by far the greater part being due to the latter process.

Carbonic acid, which supplies plants with the carbon of their tissues, is supplied by the respiration of man and animals: by combustion, and by the decomposition of saccharine matter, volcanic action, and hot springs.

The sources of ammonia are nearly the same as carbonic acid: the secretions of animals, the combustion of wood and coal, and the decomposition of nitrogenous matter.

The constituents of sap in special plants are the metallic oxides, as potassium, sodium, calcium, and magnesium. How these various substances permeate through the tissues of plants, is, to a certain extent, a mystery.

On the Growth of Vegetables.

Vegetables increase by means of the nourishing materials elaborated by the descending sap. It would be entering upon a long and difficult task to take into consideration all the points which botanists have made concerning the growth of vegetables. We must, therefore, limit ourselves here to the consideration of what actually comes under our own knowledge in the growth of trees. Trees are elongated by the development of their terminal shoots. We observe the intervals between the points of the insertion of the leaf, which at first are very short, gradually become longer according to the greater degree of development through which they have passed.

But how do trees increase in circumference? This demands a closer examination.

If we study the internal structure of a branch of one year old in one of our forest trees, we shall find that towards the end of the year the branch is arranged in the following manner. There is a pith, a fibro-vascular circle, furnished with air-vessels on its internal face, with straight medullary rays traversing the ligneous circle, losing themselves in the bark, which is composed of an epidermis of ruber, of the herbaceous envelope, and of liber. But between the ligneous and cortical system we can distinguish the presence of a special zone formed of very delicate cells, with walls soft and transparent, which in spring-time are bathed in liquid supplied abundantly by the descending sap, to which botanists give the name of *cambium*. This last layer is of the utmost importance, for we can perceive that in the course of the second year, by the process of vegetation, this intermediate zone, which is situated between the cortical and ligneous system, and

has received the name of the *generating zone*, becomes the seat of a double formation, the one cortical, the other ligneous. Fig. 137, which we have given to show the different elements of the stem of a tree, serves also to show its mode of development. That part included in the lines marked 1, represents the wood and bark of the first year, that marked 2 the wood of the second year. The generating layer separates these two elements, and is indicated by the letter *c*. Cells, fibres, and vessels result from the transformation of the delicate elements of this generating tissue. In other words, at this point the transposition of *cambium*, or bark from without to within, and of wood from within to without, takes place. The medullary rays are continued without interruption or modification across the new beds, forming itself anew, and, without

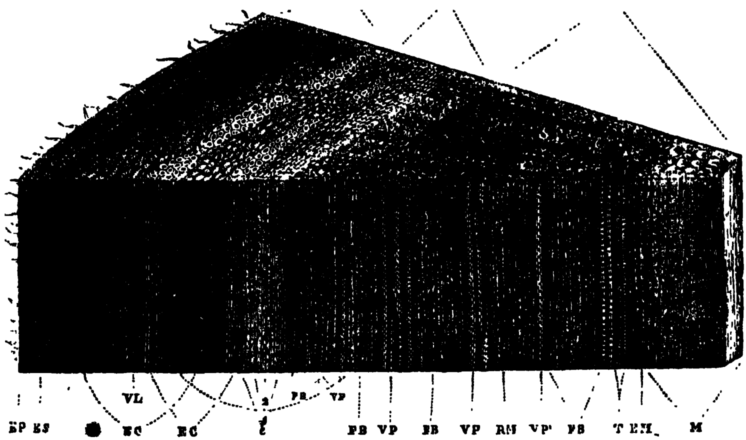


Fig. 137.—Horizontal and transverse section of the trunk of an Elm.

being in connection with the pith, prolonging itself, in short, to the bark. What passes in the second year is repeated during the third and fourth. A very useful consequence results from this. We are enabled by observing certain characters to distinguish the successive layers which form themselves year by year. The age of a tree is thus, so to speak, inscribed upon its own surface. In the oak, for example, it is very easy to distinguish the annual layers. The transformation of the generating zone in the wood

continues from spring to autumn, and consequently under climatic influences very different. The great vessels are formed at the season when the sap is most active in its circulation; then come vessels of smaller calibre and much more numerous. Towards the end of the year, when vegetation is less active, ligneous fibres are formed. It follows from these differences between the wood of spring and of the autumn, that it is very easy to distinguish the passage from the former to the latter, and that the different annual formations appear consequently as so many concentric zones on the horizontal section of the tree. To continue, it is by the operation of the generating zone that the tree increases in circumference. If the annual growth of a tree were equal during all the time of its vegetation, there would be no line of demarcation between each annual period, and consequently no concentric zones. It is thus with trees in some hot countries, where vegetation is neither checked nor accelerated by change of temperature. The age of a tree is not there, as in temperate countries, to be found inscribed upon its stem.

We must here, however, offer two important remarks. The new wood alone participates in the nature of the exterior parts of the ligneous circle; the medullary sheath is not renewed. On the other hand, new cells are constantly formed by means of the generating zone, in default of which the growth would cease as soon as all the cells of this zone were transformed into the elements of new wood and bark.

Fig. 138.—Flower of Rafflesia Arnoldi.

The Flower.

We have surveyed with wonder the wisdom and power of the Creator as displayed in the different organs and appliances just passed in review. We have admired the roots, with their innumerable tufts of fibre, which by a marvellous faculty, scarcely explicable to us, imbibe the liquids contained in the earth, and convey the nourishing fluid into the tubes of plants; the stems and branches which support the plant in mid air; the leaves, organs at once of respiration and evaporation; the vessels, so variable in form; the breathing pores (*stomata*), the cells; in short, all the appliances, all the living mechanism by means of which the vegetable functions are carried on; all tending to the production of flowers, which, in their turn, live only for the production of fruit; while the fruit itself only exists for the purpose of developing the seed, that ultimate end and essential design of vegetation; for Nature seems to concentrate all her efforts with a view

to the reproduction of the individual, and consequent preservation of the species.

But what is a flower? What definition shall we give of a flower, that can pretend to exactness, and at the same time be framed in scientific terms? A rigorous definition of the flower is more difficult than one would think. It was a saying of Linnæus that minerals grew, plants grew and lived, animals grew, lived, and felt; but this is now known to be altogether incorrect, for certain plants not only grow and live, but give every indication of feeling, witness the *Mimosa*, or Sensitive plant, which closes its leaves on being touched, and some of the most obscure plants among the *Confervæ*, which move about by the action of their own *cilia*, or hairs, until they have found a resting-place for themselves. He would, in short, be a rash man who should attempt a definition of plant or mineral in these enlightened days. Such, however, was not the opinion of Jean Jacques Rousseau, the celebrated philosopher of Geneva, who was indebted to the study and cultivation of botany for some of the happiest hours of his life. He has left, in his "Letters on Botany," a book full of interest and sound science, in which he thus expresses himself on the definition which can be given of a flower:—

"If I resigned my imagination to the pleasing sensations which this word seems to call forth, I should write a paper agreeable, perhaps, to sentimental shepherds, but very unsatisfactory to botanists. Let us put aside for a moment the vivid colours, sweet odours, and graceful forms of flowers, and try, in the first place, to understand the organised being which unites these attributes. Nothing at first sight appears easier. Who thinks he requires to be taught what a flower is? 'When no one asks me what is time,' said St. Augustine, 'I know it very well; but I do not know it when I am asked.' One might say as much of a flower, perhaps of its beauty even, which is the prey of time. I am presented with a flower, and I am told, 'Here is a flower.' This is showing it to me, I confess, but not defining it; nor will this inspection enable me to decide, in the case of any other plant, whether what I see is, or is not, a flower; for there are multitudes of vegetables which have in none of their parts the apparent colour which Ray and Tournefort have introduced into thei

definitions of a flower; and yet these vegetables bear flowers not less real than those of the rose-tree, although much less apparent."

Nevertheless, although the definition of the flower appeared to Rousseau so surrounded with difficulties, he does not hesitate to propound the following:—

"The flower," he says, "is a local and temporary part of the plant, which precedes the fecundation of the germ, in or by means of which part the fecundation is effected." This was an unexceptionable definition, which was scarcely modified a century later by Moquin-Tandon, when he said, "A flower is that temporary apparatus, more or less complicated, by means of which fecundation is effected."

The flower, then, is an apparatus composed of two envelopes, the *calyx*, the *corolla*, and the *essential organs* proper to ensure the

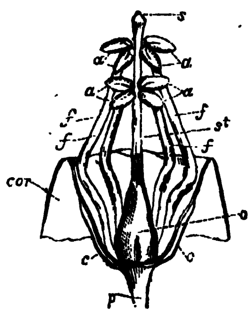


Fig. 139.—Section of the Foxglove.

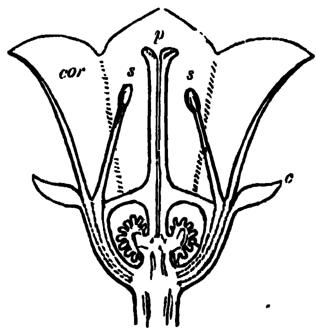


Fig. 140.—Section of the Calyx.

reproduction of the plant, namely, the *pistil*, in which the seed is afterwards enclosed, and the *stamens*, destined to fecundate the pistil. The position of the organs will be better understood by examining the following diagrams. Fig. 139 is a portion of the flower of the Foxglove (*Digitalis purpusia*), showing the stamens *f a* united with the corolla *cor*, *p*, the peduncle, or floral axis, *c*, the calyx, *o*, *st*, *s*, the pistil. Fig. 140 is an ideal figure showing how the calyx *c*, the corolla *cor*, the stamens *s*, and the pistil *p*, are consolidated throughout their basal portions.

The calyx, corolla, stamens, and pistil, are inserted on an axis called the *receptacle*, the form of which varies according to the plant. In the Strawberry, for instance, the receptacle is the

succulent fleshy part which is eaten under the name of fruit; the fruit, in fact, being the little yellow specks which cover it. It is also the core of raspberry, and club-shaped spadix of the Arum.

The flowers of every plant present only these five orders of organs. There are some which have no stamens, and others without pistil. In these two cases the flowers are said to be *unisexual*. In the first they are called *female* flowers, in the second, *male;* but both are always present, either on the same plant or on distinct plants. The Box-tree has unisexual flowers, some furnished with stamens without a pistil, others with a pistil without stamens. Other flowers are without a corolla, and some even without both calyx and corolla. The former are *incomplete,* (*monochlamydeous*), the latter are called *naked* (*achlamydeous*). The Marsh Marigold (*Caltha palustris*), which expands its magnificent golden flowers in spring along the marshy borders of rivers, ponds, or lakes, is without a corolla; the flower of the Ash has neither corolla nor calyx, but reproductive organs only.

In short, some flowers have neither calyx, corolla, nor stamens; others, neither calyx, corolla, nor pistil. They are at once *incomplete* and *naked*. The flowers of the Willow are of this sort; some are possessed of two stamens, and others of a pistil only.

A flower provided with stamens and pistil is said to be *hermaphrodite*, whether it has floral envelopes or not. There are a great many plants which bear hermaphrodite flowers only; there are others bearing, on the same individual, male, female, and hermaphrodite flowers; these are *polygamous* plants. Some plants present only male, others, again, only female flowers, and these sometimes occur on the same, and in other cases on different, plants. In the former case, as in the Chestnut, Hazle-nut, and *Ricinus*, to which the Castor Oil plant belongs, the plants are said to be *monœcious*. In the latter, as in the Hemp-plant, Date-tree, and *Merculiaris*, one of the *Euphorbiaceæ*, the plants are *diœcious*.

Plants present themselves with flowers varying as much in their dimensions as in their structure. There are flowers only the thousandth part of a foot in diameter, and some which are celebrated for their immense bulk. We find in Sumatra and the Sunda Islands a parasitical plant, the flower of which constitutes

Plate V.— *Victoria Regia*, on a river of Guiana.

nearly the whole vegetable production of the country, and is nearly nine feet in circumference. This is the *Rafflesia Arnoldi* (Fig. 138). The calyx of some of the *Aristolochiæ* on the banks of the Rio Magdalena, is so voluminous, that the inhabitants use it for a cap. The flower of *Victoria regia*, represented in Plate VI., is about forty inches in circumference. The effect produced upon Sir Robert Schomberg, when he first saw this magnificent flower on the River Berbice, is thus described:—

"It was on the 1st of January, while contending with the difficulties nature opposed in different forms to our progress up the River Berbice, that we arrived at a point where the river expanded, and formed a currentless basin. Some object on the southern extremity of this basin attracted my attention; it was impossible to form any idea what it could be; and, animating the crew to increase the rate of their paddling, we were shortly afterwards opposite the object that had raised my curiosity—a vegetable wonder. All calamities were forgotten; I felt as a botanist, and felt myself rewarded: a gigantic leaf, from five to six feet in diameter, salver-shaped, with a broad rim, of a light green above and a vivid crimson below, rested on the water. Quite in character with the wonderful leaf was the luxuriant flower, consisting of many hundred petals, passing in alternate tints from pure white to rose and pink. The smooth water was covered with the blossoms, and, as I rowed from one to the other, I always observed something new to admire." The leaves are of an orbicular form, the upper surface is bright green, and they are furnished with a rim round the margin from three to five inches in height; on the inside the rim has a green colour, and on the outside, like the under surface of the leaf, it is of a bright crimson; they have prominent ribs, which project an inch high, radiating from a common centre; these are crossed by a membrane, giving the whole the appearance of a spider's web; the whole leaf is beset with prickles, and, when young, is convolvulate. The stock of the flower is an inch thick, and studded with prickles; the calyx is four-leaved, each sepal is seven inches in length and four inches broad; the corolla covers the calyx with hundreds of petals; when first opened it is of a white colour, but subsequently changes to pink; it is very fragrant. Like all other water-lilies, its petals and stamens pass into each

other, a petal often being found surmounted with half an anther. The seeds are numerous, and imbedded in a spongy substance. This plant has by some botanists been placed in the genus *Euryale*, whilst Lindley thinks it is nearer *Nymphæa*, from which it differs in the sepals and petals being distinct, the papilla of the stigma being prolonged into a horn, and the changing colour of its petals. This splendid plant has now been successfully cultivated in many of the hot-houses of this country. Beautiful specimens are to be seen in the Royal Gardens at Kew, and at the Crystal Palace, Sydenham, at Chatsworth, Sion House, and elsewhere.

The dimensions of flowers are by no means in proportion to the plant which produces them. The flowers of the greater part of our forest trees are very inconspicuous, and little valued except by the botanist, being generally so small as to escape the ordinary observer; to study some of them, indeed, a lens must be employed. On the other hand, smaller plants often produce magnificent flowers; witness the daisy and other floral ornaments which decorate our meadows, woods, and gardens, dazzling us by the elegance of their forms, and brilliancy of their colours.

It is on the corolla especially that Nature has expended all the riches of her inexhaustible palette. The corolla is also peculiarly the seat of the sweetest perfumes of the vegetable world.

Plants with sweet-smelling flowers are more common in dry than in moist countries. On the burnt-up and naked hills of Southern France, the Thyme, Sage, and Lavender perfume the air with their aromatic scents; whilst the moist plains of Normandy exhale no vegetable aroma.

Before a flower blows, the different parts constituting it are brought closely together and compressed one against the other; they then form a *flower-bud*. The buds of all *annual* plants—that is, plants germinating, growing, flowering, and dying, all in the same year—continue to develop themselves up to the time of their full bloom. The flower-buds of certain ligneous plants, as the Lime-tree, also act in the same way. But there are other plants, as the Almond-tree, the Plum-tree, the Pear-tree, &c., in which the flower-buds appear during the summer, and increase in size up to the time of autumn. They remain stationary during winter, and

come into bloom the following spring with the first rays of the warm sun. These flower-buds are *scales* (*squamose*), that is, shut up in scaly coverings, which bear the name of *hibernacula*, or *winter quarters*. The flower-buds which spring and are developed during the warm season are said to be *naked*.

The flower-bud at last opens, blows, and passes into the state of a flower. This blooming does not take place at all times of the day indifferently. Linnæus has drawn up a list of plants arranged according to the hour at which their flowers blow. He called this list the *Floral Clock*. De Candolle has also noted the times at which the following flowers blow at Paris :—

Between 3 and 4 A.M.	Bindweed of the hedgerows.
At 5 A.M.	Naked stalked Poppy and most of the Chichoraceæ.
Between 5 and 6 A.M.	Nipple Wort and the Day Lily.
At 6 A.M.	Many of the Solanaceæ (Nightshade) family.
Between 6 and 7 A.M.	Sow Thistle and Spurrey.
At 7 A.M.	Water Lilies, Lettuces.
At 7 to 8 A.M. . . .	Venus's Looking-glass.
At 8 A.M.	Wild Pimpernel.
At 9 A.M.	Wild Marigold.
At 9 to 10 A.M. . .	Ice Plant.
At 11 A.M.	Purslain, Star of Bethlehem.
At 12	Most of the Ficoid, or Mesembryanthemum family.
At 2 P.M.	Scilla pomeridiana.
Between 5 and 6 P.M.	Silene noctiflora.
Between 6 and 7 P.M.	Marvel of Peru.
Between 7 and 8 P.M.	Cereus grandiflorus, Tree Primrose.
At 10 P.M.	Purple Convolvulus.

Some plants remain in bloom many days in succession. There are others which are ephemeral, and, opening at a fixed time, finally close up and fall off the same day at a nearly settled hour. The Cistus and Flax plant expand their green flowers about five or six o'clock in the morning, and are withered before midday. The *Cereus grandiflorus* blows at seven in the evening, and closes about midnight.

Certain equinoxial flowers open and close at a fixed time in the same day; on the morrow and for several following days, they again open and shut at the same regular hours. The Star of Bethlehem opens several days in succession at eleven in the morning, and closes at three. The *Ficoides noctiflora* blows several days in succession at seven in the evening, and closes about six or seven in the morning.

"The regularity of these phenomena," says De Candolle, "has struck all observers, but although the cause evidently is referable to the action of light, it is still difficult to verify it with precision. . . . . . . I have subjected the Marvel of Peru to continuous lamplight, and by that means have obtained an inflorescence altogether irregular; but having also placed them where they were lighted during the night, and kept in darkness during the day, I noticed that at first their flowering was very irregular. They soon became accustomed, however, to their new circumstances, and ended by blowing in the morning, that is, at the end of the day artificially made for them, and closing in the evening as their period of obscurity approached."

Heat, however, appears to have a certain influence on the time and the duration of the blowing of flowers; and it is observed that these phenomena vary in different countries, according to their latitudes, and in the same country according to the seasons. The *Floral Clock* drawn up by Linnæus at Upsal goes slower than the clock arranged by De Candolle at Paris.

In a few flowers the time of blowing is modified by the state of the atmosphere. These may be called *meteoric* plants. The Siberian Sow Thistle (*Sonchus dentatus*) never closes in the evening, it is said, when it is going to rain the next day. Several of the *Chichoraceæ* do not open in the morning when it is going to rain. The *Caltha pluvialis* is said to close its petals when the weather indicates rain, but its flowers remain open in sudden storms, which seem to take it by surprise. Facts of this kind, which are, however, neither numerous nor very trustworthy, have been used in the arrangement of a floral weather-glass.

The duration of inflorescence varies much in different species. In the Peach, Almond, and Apricot, among trees, and in the Hyacinth and Tulip among herbs, it remains in blossom for a few days only. But the Winter Hellebore remains covered with flowers the whole winter, and the Shepherd's Purse (*Capsella*) flowers from April till November.

The period at which flowering commences varies in the same way according to species. Linnæus arranged a table of the flowering of different vegetables in the climate of Upsal, in Sweden, for the year 1755, and gave to this list the name of the *Floral Calendar*.

But this calendar necessarily varies with each climate, for the date of the flowering of a plant is sooner or later, according to the latitude of the country. At Smyrna the Almond-tree blooms in the first half of February; in central France it blooms at the beginning of April; in Germany in the second half of April; at Christiana in the early days of June.

It is hardly necessary to observe here how very indispensable an exact acquaintance with the times of flowering is to those who wish to see flowers succeeding each other harmoniously and without intermission, in their gardens.

INFLORESCENCE.

The arrangement of the flowers on the vegetable is called its *inflorescence*, from *infloresco*, "I begin to blossom." It means simply the flower-head.

Schleiden, who has paid more attention to this subject than has been usual with botanists, describes the various forms of inflorescence as follows:—

I.—*Centripetal Inflorescence.*

1. The Capitulum, which is many-flowered in CALATHIUM, whose simple flowers stand on the axils of more or fewer stunted bracts, surrounded with other circles of stunted bracts, as in some of the Compositeæ.

2. The SPIKE (*Spica*) occurs in various forms, as the Catkin (*Amentum*), which falls off entire, also distinguished by its imperfect flowers, as in the male flowers of the *Betulaceæ*, and some other plants. The *Spadix*, a closely-crowded spike, with partially-cylindrical capitulum, and fleshy peduncle. The *Cone*, a cylindrical capitulum, or solid spike, on which the foliar organs become woody scales. The *Spikelet* (*Spicula*), the simple inflorescence of the grasses and *Cyperaceæ:* namely, a few-flowered spike, surrounded at the base by *Glumæ*, but with flowers having no bracts.

3. The UMBEL, or Umbellula when compound.

4. The RACEME, which, in different forms, is distinguished as the *Corymbe*, a pyramidal raceme.

II.—*Centrifugal Inflorescence.*

5. The CYME, or false umbel, is a corymbe with centrifugal inflorescence, but includes the compound raceme, umbel, and capitulum.

III.—*Once Compound Inflorescence.*

6. SPIKELETS: where several spikes unite in a spiral arrangement, as in the grasses, they become spikelets.

7. UMBELLA: where several umbels are united in umbels they become Umbella.

8. The PANICLE includes all the many-headed forms of inflorescence, as in many grasses.

9. The BUNCH, or FASCICULUS: a manifold compound cyme, with short and rather crowded pedicels.

10. The ANTHELA: the inflorescence in the *Juncaceæ* (Rushes) and *Cyperaceæ* (Reeds).

11. GLOMERULE: certain forms of inflorescence, resembling Capitulim, consisting of ill-formed, imperfect flowers, as in some nettles and rushes.

Flowers are said to be *sessile*, in the language of botanists, when they are placed immediately on the stalk, or attached immediately to the stalk by a small support, called a *peduncle*. The peduncle is what is commonly called the *stalk* of the flower, and afterward becomes the stalk of the fruit. The peduncle therefore is to flowers what the petiole is to leaves, that is, a means of attachment to the stem or branch. Nevertheless, the analogy between the peduncle and the petiole is limited to the external shape, for the two organs differ essentially in their special organisation.

Fig. 141.—Inflorescence of the Red Currant (*Ribes*).

Do the flowers, whose constituent parts we shall soon consider in detail, spring at random from the stem, the branches, or the boughs supporting them?

When we consider the admirable regularity and the rigorous laws by which leaves are arranged on the boughs, we are led *à priori* to confess that the distribution of flowers on their vegetable axes must obey very determinate laws also. This is, in fact, what is

Fig. 142.—Inflorescence in the sheath of Vervain Officinalis.

Fig. 143.—Branching raceme of the Oat.

shown us by nature. Her laws are generally easily recognised and though sometimes hidden, are never violated. Flowers are always the termination of an axis, branch, or bough, and the order governing their arrangement is only a repetition of that which regulates the ramification of the plant.

Fig. 144.—Male catkins of the Willow.

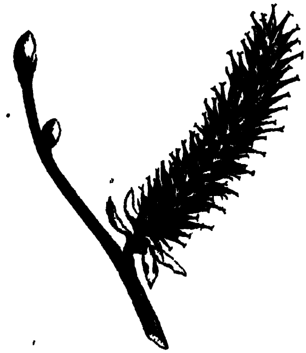


Fig. 145.—Female catkins of the Willow.

Fig. 146.—Corymbe of the Cherry.

Fig. 147.—Simple umbel of Astrantia.

Figs. 148 and 149.—Inflorescence of the Daisy.

In order to study inflorescence generally, let us take some of the more common plants and examine the arrangement of the flowers on each of them. In the Red Currant (Fig. 141), the floral axis carries at intervals modified leaves, called *bracts;* at the axil of each of these bracts the *peduncle* takes its rise, and it is terminated by a flower. This is the type of the *cluster* (or *raceme*).

The inflorescence of the Vervain (*Verbena officinalis*), Fig. 142, is only distinguished from the above by the extreme shortness of the peduncles; this constitutes a *spike.*

The Oat-plant (Fig. 143) furnishes us with an example of the modifications which the cluster experiences. Its flower is called a *branching cluster,* or raceme.

The *spike* takes the name of *catkin* or *ament,* from *amentum,* a strap, when it is formed of unisexual flowers, as represented in the *male* and *female* catkins of the Willow, Figs. 144 and 145.

In the Cherry of St. Lucia (Fig. 146), the peduncles originating in the principal axis are longer at the lower part of the axis than they are towards the summit, so that the whole of the flowers form together a sort of umbel with unequal ribs; this cluster is called a *corymbe.*

In the Astrantia (Fig. 147), so called from its star-like flowers, the axis of inflorescence is very short, and bears at the extremity, which is enlarged, a certain number of secondary axils, rather elongated, and of equal length, so that the flowers seem to spring from the same point in order to attain the same height. Here the umbel has equal ribs, and the group of flowers is said to be *umbelliferous.*

In the Daisy (Figs. 148, 149) the numerous sessile flowers are inserted on the surface of an enlarged and flattened axis, and form a *capitulum,* or head. The capitulum is influenced by the form of the receptacle: when the latter is spherical, the capitulum is globular; when flat, concave, or convex, the capitulum varies accordingly.

All these modes of inflorescence are only modifications of one of them, which may be taken as a type, namely, the *cluster.* They sometimes seem to attain a certain degree of complication, without having the simplicity of their guiding rule thereby diminished.

Thus, in the Nettle-tree (Fig. 150) the clusters of flowers are

Fig. 150.—Compound corymb of the Nettle-tree.

Fig. 151.—Compound umbel of the Chervil.

Fig. 152.—Compound raceme of the Vine.

arranged in a corymb. In the Carrot and Chervil, Fig. 151, the umbels rising from the summit of the stem, each pedicel has an umbel on its summit, when they become a compound umbel. In the Privet, and the Vine, Fig. 152, the inflorescence is formed of small clusters, being again arranged in larger clusters, or panicles.

Fig. 153.—Compound spike of Wheat.

Fig. 154.—Dichotomous cyme of Centaury.

In the Wheat-plant, Fig. 153, the ears are grouped in spikes. There are, then, *compound corymbs*, *compound umbels*, *compound clusters*, or *panicles*, and *compound spikes*.

In every case hitherto mentioned, the number of flowers of the same generation are indeterminate in each group. This will not be the case in the following instances.

Let us examine, for example, the method of arrangement in the flowers of the Centaury (*Erythræa Centaurium*), Fig. 154. The main stem terminates with a flower, and a little below this the stem bears two opposite leaves or *bracts*. From the axil of each of these arises a secondary branch, terminated also in two leaves and a flower. Each of these branches comport themselves in the same way as the stem, that is, they give birth to two tertiary branches,

Fig. 155.—Inflorescence of Myosotis.

Fig. 156.—Spathe of Arum maculatum.

each terminating in a flower, and thus it goes on. We thus see that at each branching out, the number of flowers is doubled. We see besides, that the flowering in this plant goes from the base to the summit, or, which comes to the same thing, from the centre to the circumference. This sort of inflorescence bears the name of a *cyme*, and in this particular case is said to be *dichotomous*,

from $\delta\iota\chi\alpha$ and $\tau\epsilon\mu\nu\omega$, "by pairs I divide." In some cases three whorled bracts develop axes from their axils, when the cyme is said to be *trichotomous*, divided by threes.

The inflorescence of the Forget-me-not (*Myosotis*), and the Heliotrope, also form *cymes*. As in these plants the multiplying axis of inflorescence often tends to form a curling inflorescence, very unfitly compared to the tail of a scorpion, the cyme of the Forget-me-not and Heliotrope are said in consequence to be *scorpioidal* (Fig. 155).

In the Horse Chesnut, the principal axis bears an indeterminate number of small scorpioidal cymes. This is an inflorescence mixed up of the two principal forms we have already pointed out, and is a *cluster of scorpioidal cymes*.

When a succulent spike is enclosed within a *spathe*, it is said to be *spadix*, from $\sigma\pi\alpha\delta\iota\xi$, a palm branch with its fruit. In this case the axis is usually elongated beyond the flowers in the form of a club-shaped cellular organ, as in the Cuckoo-pint (*Arum maculatum*), Fig. 156, or the axis only bears flowers at its base, which is here enclosed by the spathe.

The general name of *involucre* is given to a more or less considerable collection of bracts, disposed in *whorls* (*verticils*) in either one or several ranks, which surround and seem to protect the flowers (the *capitulum* of composite flowers), yet in the natural group of *Arums*, the involucre is monophyllous, and is called a *spathe*. It envelopes the inflorescence before the blowing of the flowers. We show in Fig. 156 the spathe of the *Arum maculatum*.

We should exhaust the attention of the reader were we to enlarge more on inflorescence, a subject which we have only glanced at, but which has been the object of profound study on the part of botanists. We now come to the consideration of the constituting parts of the flower.

THE CALYX.

The *calyx*, $\kappa\alpha\lambda\upsilon\xi$, "the cup which holds the flower," is the external envelope of the flower. It has neither the elegant shape nor the varied colours of the corolla, usually appearing as a little green cup, on which the corolla rests. On account of its appear-

ance and colour, it is almost always confounded with the peduncle, of which it appears to be a mere prolongation, an expansion which afterwards subdivides into several lobes.

The simple form of the calyx is suited, however, to its functions. It is, in general, not elegance or delicacy, but firmness and solidity, which are able to protect or defend. As the calyx forms the external envelope of the flower, it must be constituted so as to resist action from without. It is true that the calyx of some plants, such as the Fuchsia (Fig. 157), rivals the corolla in elegance and beauty, but these are exceptions to the general facts.

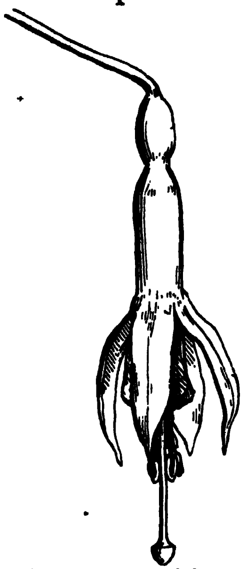


Fig. 157.—The Fuchsia.

The calyx is, then, the external envelope of the flower, and its different parts bear the name of *sepals*.

These sepals, however, are only modified leaves. If we glance at the Camelia-bud (Fig. 158), the same structure, the same nervature, almost the same form, will be observed to belong both to the five sepals of the flower, and to the bracts accompanying them. In the Peony, and Foxglove (Fig. 159), there is still a resemblance, or rather an insensible transition, between the bracts and the sepals. When we notice the various transitions of appearance, form, and size between bracts and leaves, we are led of necessity to consider the calyx of flowers as proceeding from a modification of the leaves.

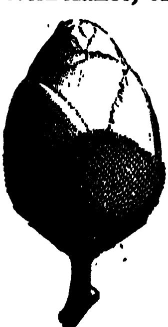


Fig. 158.—Calyx of the Camelia.

The calyx seems sometimes to be formed all in one piece, and sometimes it is more or less deeply divided. In the former case it is *monosepalous*, in the latter it is *polysepalous*.

The flower of the Primrose (Fig. 160) has a monosepalous calyx, that of the Flax-plant (Fig. 161) has a polysepalous calyx.

Ancient authors considered the calyx as an entire organ, which was sometimes cut more or less deeply. To this false idea we owe

the defective expressions, *strap-shaped*, *scalloped*, *lobed*, *dentated*, &c., by which the free parts of the leaflets of the calyx joined in one whole have been described.

The intersections, in fact, do not reach from top to bottom. When a calyx begins to show itself, its elements, the *sepals*, are always free. In a polysepalous calyx they remain isolated until fully developed, but if the calyx is monosepalous, they are supported up to a certain point by a sort of belt.


Fig. 159.—Calyx of Digitalis.

Without dwelling here on the different shapes the sepals assume, we will content ourselves with stating that these organs become indistinguishable in the Valerians (Fig. 162) and Groundsel (Fig. 163), and a host of other similar plants. They appear in these plants like a bunch of silk or hair called a *tuft*, and if we did not arrive at this curious modification by a series of appropriate examples, it would be very difficult to ascribe to the sepals their real origin.

The number of sepals in a calyx is extremely variable. There are two in the Celandine, three in the Virginian Spider-wort, four in the Willow-herb, five in the Hellebore, six in the Barberry, and a considerably larger number in the Cacti.

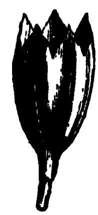


Fig. 160.—Monosepalous calyx of the Primrose.

With regard to their arrangement on the receptacle, the sepals are sometimes in a whorl (or verticil), that is, several placed at


Fig. 161.—Polysepalous calyx of Linum.


Fig. 162.—Tufted Calyx of Valerian.

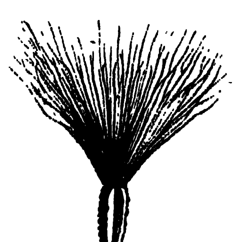


Fig. 163.—Tufted Calyx of Groundsel.

the same level, if the receptacle is conical, or at an equal distance from the centre, if the receptacle is flat; some are disposed

spirally, that is, at different heights, so that the line uniting their bases is a spiral.

Sepals are, in short, either alike in size, inserted at the same height or distance, free or united, or else they do not show a perfect agreement in these points, and thus determine whether the calyx be *regular* or *irregular*. That of the Money-wort (Fig. 164) is regular, and that of the Aconite (Fig. 165) is irregular.

Fig. 164.—Regular calyx of Loosestrife.

In the Poppy, the calyx falls before the flower blows, in the Ranunculus it is not detached until after the fecundation of the flower. In the Physalis it remains round the fruit, very much enlarges, and becomes of a yellow or reddish colour.

This last phenomenon of colouration brings us to a reflection which has its interest. In some cases where the calyx and the corolla exist simultaneously in the flower, the calyx becomes coloured, and thus puts on the appearance of a corolla. The calyx of the Pomegranate and that of the Fuchsia are red, that of the Larkspur and of the Aconite are blue. The calyx may thus be coloured even when the corolla is wanting.

Fig. 165.—Irregular calyx of Aconite.

The Corolla.

All that we have said about the charming sweetnessof flowers applies particularly to the *corolla*, for on that organ nature lavishes her brightest colours. In spite, however, of the beauty and elegance of shape which we admire in it, the corolla is only the immediate envelope of more important organs, which with the help of the calyx, it protects against the action of external causes. When the fundamental phenomenon of fecundation is effected: when the fertilised ovary begins to enlarge, and can of itself oppose a sufficient resistance; then nature, which suffers nothing useless to exist, throws away this graceful decoration: the corolla fades, withers, and falls. If it remains occasionally a short time after fecundation, it is probably only to reflect the rays of external

heat, and concentrate them on the fertilised ovary, thus accelerating its development.

The corolla is the inner envelope of the essential organs of the flower. It differs generally from the calyx in being of a more delicate tissue. The corolla alone constitutes the flower in the eyes of the world generally, but to a botanist the stamens and pistil are the essence of the flower, for under the influence of the stamens the pistil produces fruit, the seeds of which will perpetuate the species.

The *petals* are organs which, when taken together, constitute the corolla. They take their rise, like sepals, from modified leaves, a fact which is easily established. In some flowers, the Calycanthus, for instance, the petals are so completely shaded off with the sepals, that it is impossible to say where the calyx ends or where the corolla begins. In fact, the external divisions of these flowers are of a greenish hue, the internal parts being of a purple tint; but it is impossible to allot the intermediate divisions to one of the floral envelopes more than to the other. As the petals are

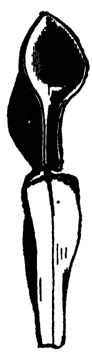


Fig. 166.—Petal of Dielytra.

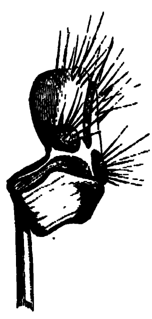


Fig. 167.—Petal of Fennel.

Fig. 168.—Petal of the Columbine.

Fig. 169.—Petal of Aconite.

shaded off into the sepals, the latter into the bracts, and the bracts into the leaves, we must conclude from this fact also that the petals are really modified leaves.

Like leaves, petals offer to us very different forms and most varied dimensions. They are generally either linear, oblong, elliptical, oval, or rounded. Sometimes they are boat-shaped,

as in the *Blumenbachia insignis.* Sometimes they take the form of a spoon, as in the *Dielytra spectabilis* (Fig. 166); sometimes they show two lips, as in the Fennel-flower (Fig. 167); sometimes they are elongated like a horn, as in the Columbine (Fig. 168); sometimes they are helmet-shaped, as in the Aconite (Fig. 169).

Petals, like leaves, are either entire or indented. They present, like them, a sort of skeleton, if one may give that name to vascular and slender ramifications, which can only be perceived clearly in some cases by placing the petal between the eye and the light, so as to look at them as at a transparency.

The veins determine the shape assumed by the petal. Figs. 170, 171, and 172 give an idea of the three principal forms for the

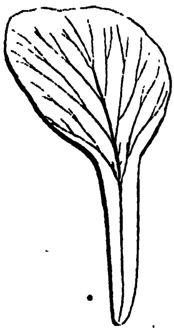


Fig. 170—Petal of Wallflower.

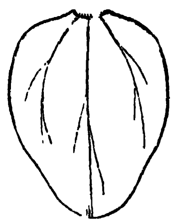


Fig. 171.—Petal of Winter Hellebore.

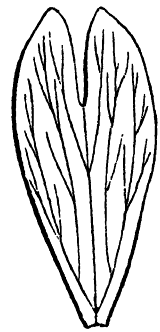


Fig. 172.—Cerastium precox.

distribution of the veins. We know that in the Wallflower (Fig. 170) the petal is elongated at its lower part by a slender portion called the claw (*unguis*), the larger part of the petal taking, in this latter case, the name of the *limb.* The petals of the *Cerastium precox* (Fig. 172) and Winter Hellebore (Fig. 171) have no claw, and, as we see, one limb only.

The number of petals in a corolla vary much; they are sometimes very numerous, and are then arranged in a spiral form; but they are oftener few in number, and are then arranged in one whorl. In the Cactus the petals are extremely numerous, and arranged in a spiral, continuous with that of the sepals. In the Geranium (Fig. 173), Violet, and Gilliflower (Fig. 174), there are only five petals arranged in a whorl.

Just as the calyx may be monosepalous, or polysepalous, so the corolla is monopetalous or polypetalous. The flower of the

Fig. 173.—Flower of Geranium.

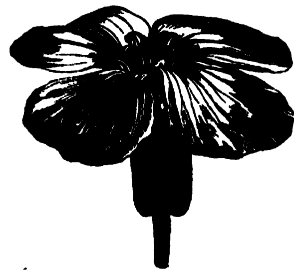


Fig. 174.—Flower of Gilliflower.

Geranium (Fig. 173), and of the Rose, and Pink, have their petals perfectly distinct, so that one can be detached without interfering with the others. On the contrary, the Lilac (Fig. 175), the Primrose, and the Belladonna, have their petals united together at their edges, so that one cannot pull off a petal without breaking in on an adjacent one.

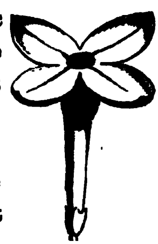


Fig. 175.—Monopetalous corolla of Lilac.

When a flower begins to expand, the petals are always free. The transformation of a corolla, at first monopetalous, into a polypetalous corolla, takes place in the bud, just as we have already shown to be the case with the calyx; that is, the free extremities of the petals are supported and united in one whole by a common and continuous membrane.

We have remarked, that the sepals are developed on the receptacle in succession, whilst the petals appear, on the contrary, simultaneously. This fact may help us to resolve a problem, which much occupied the attention of the older botanists.

In the Lily (Fig. 176), for instance, the floral envelopes are composed of six divisions, which are white, and of a delicate tissue, analogous to petals. Do the whole of these divisions constitute a corolla? By no means. Without mentioning the differences of shape, size, structure, and position, which could not escape the eyes of an attentive observer, we can show that the pieces of the external whorl of the Lily are developed in succession, like sepals,

and that the pieces of the internal whorl are developed simultaneously. It has been decided from this fact that, in spite of appearances, there is in the Lily a calyx and a corolla; in other words, the Lily has a *petaloid corolla.*

Fig. 176.—Petaloide corolla of Lilium.

In Rushes, on the other hand, contrary to what takes place in the Lily, we find a sort of double calyx. Considerations analogous to those mentioned have led botanists to concede to these plants a true corolla. We must admit, then, that in the Lily the calyx is white and petaloid, and in Rushes that the corolla is green and sepaloid.

Let us glance at the principal forms of the corolla when it is monopetalous and regular. The six principal forms which the corolla assumes need not be otherwise described than by the annexed figures and the denominations which indicate them. The corolla is *infundibuliform,* that is, like a funnel, in the Tobacco-plant (Fig. 177), *tubular* in the Comfrey (Fig. 178), *campanulate* or bell-shaped in Bindweed (Fig. 179) and the Campanula, *hypocrateriform* or salver-shaped in the Lilac (Fig. 180) or in the Jessamine, *rosaceous* in Borage (Fig. 181) or in the Willow-herb, *urceolate* or urn-shaped in the Arbutus (Fig. 182).

When the corolla is monopetalous and irregular, its principal forms are reduced to three. In the Sage (Fig. 183), or the Dead Nettle, &c., the limb of the corolla placed at the summit of a more or less elongated tube is divided transversely into two parts called lips (*labia*); the upper lip, presenting two divisions, is formed by two petals united almost to the summit; the lower lip, presenting three divisions, is formed by three petals joined more or less high

Fig. 177.—Tobacco-plant.

Fig. 178.—Tubular corolla of Comfrey Officinale.

Fig. 179.—Corolla of Bindweed.

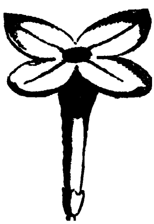


Fig. 180.—Hypocrateriform corolla of Lilac.

Fig. 181.—Rosaceous corolla of Borage.

Fig. 182.—Urceolate corolla of Arbutus.

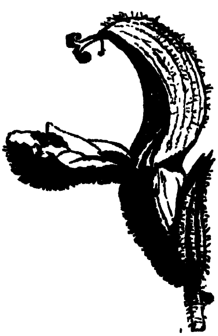


Fig. 183.—Bilabiate corolla of the Sage (*Salvia*).

Fig. 184.—Corolla of Snap-dragon.

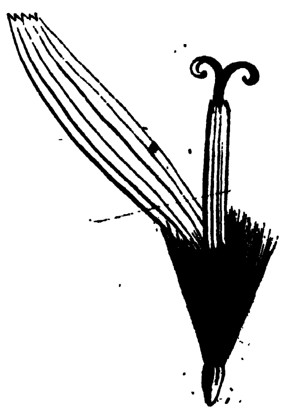


Fig. 185.—Ligulate corolla of the Dandelion.

up. This form of corolla, said to be *labiate*, characterises a very important group of the vegetable kingdom.

In the Snap-dragon (Fig. 184) the mouth of the labiate corolla, instead of being wide open, is closed by a swelling of the upper lip.

"Among the irregular monopetalous plants," says Jean Jacques Rousseau, "there is a family whose appearance is so marked, that we can easily distinguish its members by their look. It is that to which we give the name of gaping plants, because their flowers are divided by two lips, the opening of which, whether natural or produced by a slight pressure of the fingers, gives them the look of a gaping mouth. This family is subdivided into two sections or races, one with flowers having lips, or *labiate*, the other with flowers in a mask, or *personate*, for the Latin word *personæ* signifies a mask—a very fit name, assuredly, for most of those whom we call persons."

In the Endive, or the Dandelion (Fig. 185), the corolla, cylindrical at its lower part, is bent on one side, and displays a little flat tongue, terminating in several small teeth. This form of corolla is said to be *ligulated*, and belongs to a considerable number of plants composing the largest natural group in all the vegetable kingdom, that of the *Compositeæ*.

In regular polypetalous corollas, Tournefort distinguished three principal forms, which we meet with in a great number of flowers, in general those of the same family.

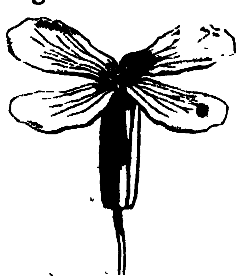


Fig. 186.—Cruciform corolla of Mustard.

Cruciform corollas have four petals arranged in a cross, and generally provided with a claw—the characteristic peculiar to plants of the group of *Crucifereæ*. Fig. 186 represents the cruciform corolla of the Mustard Plant. Caryophyllaceous corollas have five petals, with a very long claw, hidden by the calyx. No. 187 represents a corolla of this kind, that of the Pink. The *rosaceous* corollas have five petals without *hooks*, and open, arranged as in the Common Rose. (Fig. 188.)

Tournefort also classed all the modifications of the irregular, polypetalous corolla, under two names: these were *papilionaceous*

and *anomalous* corollas. The Pea (Figs. 189 and 190) has papi-

Fig. 187.—Caryophyllaceous corolla of the Pink.

Fig. 188.—Rosaceous corolla of the Red Rose.

lionaceous, the *Aconite* an anomalous, corolla. Let us dwell a little on the first of these shapes.

"The first portion of the corolla," says Rousseau, in his third "Letter on Botany," "is a large and broad petal covering the others, and occupying the upper part of the corolla, for which reason this large petal has taken the name of *canopy*. It is also called the *Standard*. We must close both our eyes and our minds not to perceive that this petal is placed there as an umbrella to guard that which it covers from atmospheric injuries. By lifting up this canopy, you will remark, that it is jointed into the side pieces on each side by a little ear, in such a manner, that its position cannot be disturbed by the wind.

Fig. 189.—Papilionaceous corolla of the Pea.

"The canopy being removed, discovers the two lateral limbs to which it was attached by its little ear pieces. You will find, on detaching them, that they are fastened still more strongly into the remaining part, and cannot be separated from it without some effort. So the

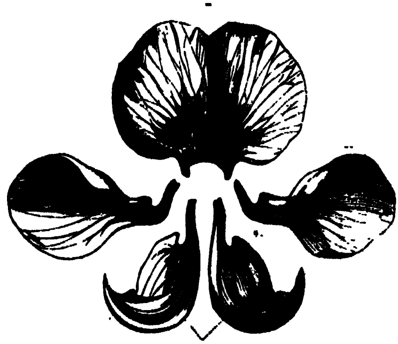


Fig. 190.—Separate parts of the corolla of the Pea.

wings are not at all less useful in strengthening the sides of the flower, than the canopy is in covering it. When the wings are taken away, you see the last piece of the corolla, the piece which covers and defends the centre of the flower, and envelopes it, especially over it, as carefully as the three other petals envelope it above and at the sides. This last piece, which, on account of its shape, is called the *keel*, is like a strong box in which nature places its treasure beyond the reach of injuries arising from the air and water."

Rousseau describes here the flower of the Pea, as an application of the principles which he had first laid down.

The Stamens.

Immediately within the petals is a fleshy disk, which has grown round the ovary, and from which spring the petals and stamens—the latter, the organs of reproduction and essential parts of the plant. They are placed within the corolla, and immediately surround the central point or pistil. They vary greatly in number, from one to fifty, and even more. They occupy the third verticil of the floral organs.

The stamen generally consists of two parts, an upper and thick portion, and a lower portion generally elongated and slender. The former is called the *anther;* the latter the *filament.* The filament is much less important than the anther, and is often wanting. The rudiment of the anther is at first a cellular mass, but when it has attained a given size, larger cells appear in its interior, usually at four distant points. By their augmentation four separate clusters are produced, around which smaller cells are arranged in a given order, forming a special cellular covering. In due time these absorb the surrounding cellular matter. Sometimes they unite into two masses (two becoming one) by the absorption of the cellular matter between them. In these cells *pollen* is now formed by the division of each cell, first into two and then into four smaller cells, which gradually change into pollen, the mother cells being either absorbed or remaining in the

form of filamentary gelatinous elastic matter among the ripe pollen. The several parts of the anther are distinguished by the term *connective*, which is the direct continuation of the filamen in the anther. The lobes of the anther are its halves, each half being a lobe or hollow cavity called a cell, being distinguished as many or single celled. It can easily be understood of the connective that if the filament and the connective were prolonged in the same direction, and of nearly the same thickness, as in the Iris (Fig. 191), the anther would be immovable, but that this would not be the case if the connective were inserted in the attenuated extremity of the filament by a point only, as happens in the Amaryllis (Fig. 192). It will also be understood that the powdery matter contained in the cells of the anther is pollen, or fine dust. That the membranous sides or walls of the cells of the anther are its valves, and that the lines which pass down the sides of the anther are the sutures or seams.

Fig. 191.—Stamens of Iris.

We have stated above that the anther is generally formed of two lobes, yet in some plants the anthers are *unilocular*; either the two lobes existing at first have been blended in one, or there was actually but one lobe, as in the *Epacridaceæ*, a family of elegant heaths from New Holland. In other plants, as the Laurels and the *Ephedra*, the anthers are *quadrilocular*.

In the art of fecundation the lobes of the anther open at the sectures in order to discharge the fertilising pollen. Generally each lobe presents a longitudinal cleft, along which the opening of the anther takes place, this being called its *dehiscence*, in botanical language. Sometimes the cleft only extends a short distance towards the summit of the lobe, and constitutes a sort of pore, as we see in the Heaths and Solanums (Fig. 193).

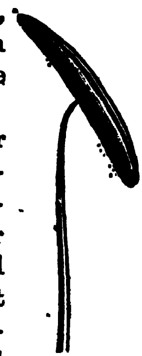


Fig 192.—Anther of Amaryllis.

In the Barberry (Fig. 194) and the Laurel (Fig. 195) a very remarkable and elegant mode of dehiscence is observable: a certain restricted portion of the walls of the anther opens upwards, so as to form little trap-doors or valves. There is one valve for

each lobe in the Barberry, and two for each lobe in the Persian Laurel, as represented in the engravings.

A familiar acquaintance with the microscopic structure of the

Fig. 193. Fig. 194. Fig. 195.
Stamens of Solanum, Barberry, and Persian Laurel.

pollen of vegetables gives rise to some very curious speculations. When a microscope of considerable power is employed, we find that the forms of these grains vary very considerably in different species, some of their forms being of a very elegant description.

The pollen-grain is generally composed of a sort of double covering, the innermost containing a mucilaginous liquid, named *florilla.* Figs. 196 and 197 are the pollen-grains of the Hollyhock, having a sort of double *sac* or covering surrounding each grain. The external membrane of the globule of pollen is smooth, dotted, granulated. It is covered with small prickles, or finely reticulated, according to the species. It also exhibits folds and pores. In the pollen of Wheat (Fig. 198) there is only one pore; in the Primrose-tree (Fig. 199) there are three. Figs. 200, 201, and 202 show the pollen grains of Garlick, the Phlox, and the Melon. The number of pores in a pollen-grain may reach five or even eight. These pores perform important functions, as we shall soon see.

When a grain of pollen is placed in water it swells, because it absorbs a certain quantity of the liquid. Its membranes expand, and the internal one protrudes through the pores of the external membrane. The vessel bursts, and the florilla escapes in a sort of mucous and granulous jet. This is an anomalous but very curious phenomenon to observe. It is anomalous, because it is not thus

that the matter takes place in nature. When a pollen-grain falls on the moist and viscous surface of the pistil, which we shall soon describe, and which bears the name of *stigma*, it expands slowly, appearing to absorb its humidity; the interior mem-

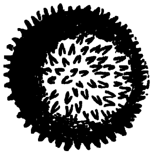


Fig. 196.—Pollen of the Holyhock, first Envelope.

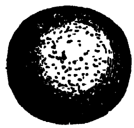


Fig. 197.—Second Envelope.

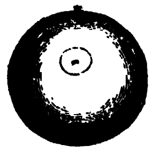


Fig. 198.—Pollen of Wheat.

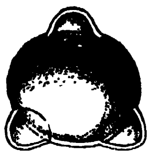


Fig. 199.—Of Primrose-tree.

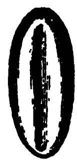


Fig. 200.—Of Garlic.

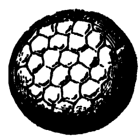


Fig. 201.—Of the Phlox.

Fig. 202.—Of the Melon.

brane becomes gradually extended and protruded through one or two pores in the exterior coating, in the form of delicate tubular protrusions, which lengthen by degrees, and end by forming real tubes, called *pollen-tubes*.

The length of these tubes varies considerably; they attain in certain cases many hundred times that of the pollen-grain, which gave it birth. This prodigious lengthening evidently cannot proceed from a mere elongation of the internal membrane of the pollen-grain, but is the result of an actual growth in this membrane. The pollen-tube is nourished and grows, that is to say, it *vegetates;* so that, leaving the stigma, it penetrates into the tissues, which it is intended to traverse. We shall have occasion to return to the pollen-tube when we speak of *fecundation* in the next section.

Although pollen-grains are almost always free and distinct, there are some plants in which these grains are joined together, and often very closely. In the *Orchidaceæ* (Fig. 203), the pollen is gathered together into masses, sometimes almost pulverulent, with loosely-cohering granules; sometimes it is formed of numerous small angular masses, joined together by means of glutinous

matter. In *Plantanthera chloranta*, and *Asclepias floribunda*, the masses of pollen show the arrangement as represented by Figs. 204 and 205.

The number of stamens in each flower varies according to the

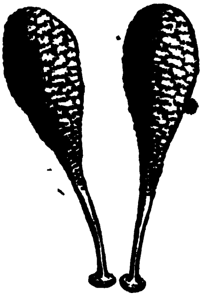


Fig. 203.—Pollen Mass in Orchis maculata.

Fig. 204.—Pollen Mass of Plantanthera chloranta.

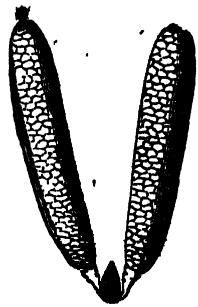


Fig. 205.—Pollen Mass of Asclepias floribunda.

species. When they are arranged in *whorls*, they are generally definite in number, as in the Vine (Fig. 206), and the Primrose, which have five. When they are in a spiral, they are usually very numerous, as in the Magnolia and the Ranunculus.

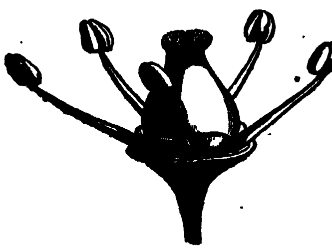


Fig. 206.—Androecium Stamens of the Vine.

Stamens may be all of the same height, as we see in the Lily, Tulip, and Barrage, or else very unequal. In the Geranium, there are five stamens bigger than the others, which are also five in number. In the Wallflower (Fig. 207), which has six stamens, four are bigger than the others; Linnæus called these *tetradynamous*. In the Snap-dragon (Fig. 208), there are four stamens, two of which are larger than the others; Linnæus called them *didynamous* stamens.

The stamens of the same flower may be completely independent one of the other, or more or less united either by their filaments or by their anthers. In the Mallow (Fig. 209), and in the Flax plant, all the stamens are united to each other by their filaments in a single bundle. In the French Bean, and the Milk-worts, they

are united in two bundles; in the Egyptian St. John's Wort (Fig. 210),

Fig. 207.—Androcœum of the Wallflower.

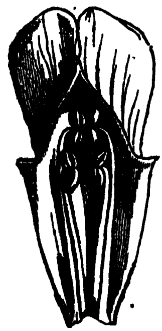


Fig. 208.—Androcœum of the Snap-dragon.

Fig. 209.—Androcœum of the Mallow.

in three bundles; in the Ricinus (Fig. 211), in several bundles.

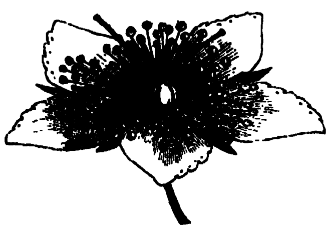


Fig. 210.—Androcœum of St. John's Wort.

Fig. 211.—Stamens of Ricinus (Castor-Oil-tree).

After Linnæus, the stamens are called *monadelphous*, *diadelphous*, *triadelphous*, *polyadelphous*, as they form one, two, three, or more bundles. In the Dandelion, Artichoke, and Thistle, the stamens are joined together by their anthers, so as to form a kind of tube, supported by free filaments: these are said to be *synantherous* (Fig. 212).

Finally, stamens may form adhesions with the floral envelopes. In the Squill, for instance, six stamens adhere by their base to the six divisions of the flower. In the Primrose, five stamens are attached to the tube of the corolla, which is monopetalous.

Fig. 212.—Synantherous Stamens.

We shall conclude our remarks on the stamens by some inquiry into the morphological nature of this part of the flower.

Bracts, sepals, and petals are modified leaves, as we have seen. It appears difficult to believe, at first sight, that the same should be the case with stamens. Yet, pick the petals from a flower of the White Water-Lily; you will observe, as you approach the centre of the flower, that the petals diminish in length and breadth, and present towards the summit, an anther, at first rudimentary; this becomes more and more complete as the supporters pass insensibly from the form of a petal to that of a filament. In the Columbine, under the influence of cultivation, we see the stamens changing by degrees into forms analogous to those constituting its elegant corolla. In the Rose, we often find organs which are half petal and half stamen.

There is a very curious monstrosity in one species of the Rose, in which all the organs of the flower are transformed into leaves, so as to constitute what horticulturists call a *monster rose*. In this production we can follow, step by step, all the transformations between an almost perfect stamen, and a petal which has been transformed into a green leaf.

All these facts demonstrate that the stamen is only a metamorphosed petal. But we have already shown the analogy of petals with sepals, of sepals with bracts, and of bracts with leaves. Stamens, therefore, like these organs, are only metamorphosed leaves. In short, the *filament* of the stamen has been compared to the claw of the petal, or the *petiole* of the leaf, the *limb* to the leaf itself, the pollen to a special modification of the *parenchyma* of the leaf, also the *connective* to the central part, that is, the *mid-rib* of the leaf.

The Pistil.

As we advance in the study of the organic parts of plants, it will be observed, that nature is constantly approaching her essential object, the propagation and preservation of the species. The pistil is the essential organ in the reproduction of plants; Nature, therefore, has taken care to collect round the pistil all possible means for its protection and defence. It is placed in the centre of the flower, sheltered under several concentric coverings, and defended

besides, externally, by the filaments of the stamens, which form a rampart round it. These various floral envelopes last as long as the pistil needs their protection and shelter. They disappear after fecundation, when the ovary is strengthened by its own proper development.

The pistil is the female organ in vegetables, the *gynæcium*, as it is sometimes called, as opposed to the *androcæum*, the name which designates the whole of the stamens, or the male organ.

The gynæcium presents one of the most remarkable applications of the doctrine of *vegetable metamorphosis*, made popular by Goëthe, the celebrated German poet, and also a profound naturalist. We can easily understand the structure, origin, and arrangement of the gynæcium, if we consider it as constituted by the transformation of a single leaf, or rather as resulting from the union, blending, and combination of several leaves in one single organ.

The elementary organs, the junction of which forms the pistil, are called by De Candolle, *carpels*. The carpel is to the pistil what the sepal is to the calyx, the petal to the corolla, and the stamens to the androcæum. The union of the carpels generally forms the pistil, as the union of the petals form the corolla, and the union of the stamens the androcæum. Sepals, petals, and stamens, are only modified leaves; it is just the same with the carpel, which takes its rise during the phases of vegetation by the metamorphosis of the leaves.

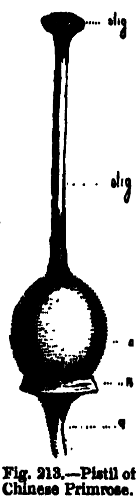


Fig. 213.—Pistil of Chinese Primrose.

Three parts are observable in the pistil—the *ovary*, the *style*, and the *stigma*. These three parts are very apparent in Fig. 213, representing the pistil of the Chinese Primrose, where the letters *stig.* indicate the stigma, the letters *sty.*, the style, by the letter *o*, the ovary.

The ovary is the part of the vegetable destined to contain the seed, that is, the *ovules*, which, when fertilised and developed, become the *seeds*. The part which supports the ovules, which is generally rather thick, is called the *placenta*; it is indicated in Fig. 213 by the letter *p*, above the receptacle *r*.

The top of the ovary is prolonged by a filament, either long or

short, which is called the *style*, and is analogous to the mid-rib in leaves. The style carries a glandular appurtenance on its summit, destined to receive the pollen-grains, and to help fecundation; this is the *stigma*.

The style is not a solid cylinder, as we might think at first sight; on the contrary, its axis forms a sort of canal leading into the ovary, and descending to the vicinity of the ovules. The stigma, which is the upper part of the pistil, is very variable in form; it is essentially formed by a mass of thin, transparent cells, loosely united and coated over with a gummy, mucilaginous matter. It is thus perfectly well fitted to receive and retain the pollen-grains.

The carpels have a greater tendency than the more external organs to unite with each other: this is, no doubt, either owing to their proximity, or to the pressure of the external organs, assisted by their position in regard to each other. This junction takes place either by the ovaries alone, or by the ovaries, styles, and stigmas, or by the stigmas alone.

Fig. 214.—Pistil of Fœtid Hellebore.

When two or more carpels are united by means of the ovaries, an ovary results composed of several partial ones, there being as many cells as there were carpels at first. In the Bastard Hellebore (Fig. 214) the junction of the ovaries takes place at the base only; in the Corn-cockle (Fig. 215), about half way up. But most frequently the junction takes place at the summit.

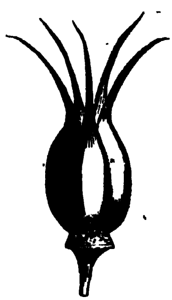


Fig. 215.—Ovary of Fennel Flower.

When the styles are joined together, at least in some observable portions of their length, there results from this cohesion a style single in appearance, but in reality constituted by as many partial styles as there were carpels. In this case the number of free stigmas will, if they are simple, indicate the number of cells in the ovary. The partial stigmas may also unite, and constitute a stigma, in appearance single, but often so divided as to indicate by the number of its divisions the number of carpels constituting the pistil. The

absolute number of cells in a pluri-locular ovary is subject to variation, but is generally three, then comes the number two and five, but very rarely four. This number, besides, is not always the same in the different ages of the flower; it sometimes happens that they are multiplied by the formation of partitions, afterwards further developed, as in the Vervains and the *Labiateæ*, which, at first, have only two cells, but later show four, by the partition of each of the primitive cells into two compartments. This is also seen in the Flax-plants, the five primitive cells of which divide at a given time into two, by a partition of new formation. These supplementary partitions which thus mask the first structure of the ovary, are called *spurious dissepiments*.

The ovary is usually apparent or free, and perceptible by looking into the bottom of the flower; it is then called a *superior ovary*, as in the Poppy (Fig. 216) and Lily. At other times only the summit of the ovary shows itself at the bottom of the flower, and it is united with the receptacle, and must be looked for underneath the flower; the ovary is then called *inferior* or *adherent*, as in the Coffee-plant, Madder (Fig. 217), and Melon-plants.

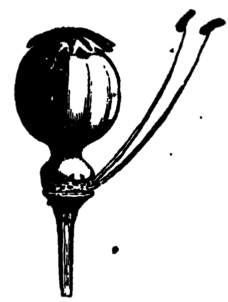


Fig. 216.—Ovary of the Poppy.

We have stated above that the small bodies attached to the placenta are called *ovules*, and that afterwards they become seeds. These ovules are composed of a small central body or *nucleus*, adhering by its base to a double sac, showing only a very small aperture corresponding to the free summit of the *nucleus*. The external sac is called *primine*, and the internal sac *secundine*. The aperture of this double envelope is the *microphyle*. The point of adhesion of the nucleus with its integuments is called the *chalaza*. Some ovules have no *primine*, and some have neither *primine* nor *secundine*. But these cases are rare. The point at which the ovules are attached to the placenta, either directly or indirectly by means of a small thread or *funiculus*, bears the name of *hilum*.

Fig. 217.—Ovary of the Madder Root.

Ovules are not all of the same form. The ovule of Rhubarb

(Fig. 218) is shaped like an egg. Its *hilum* is diametrically opposite to the *microphyle*. This kind of ovule is called *orthotropal*.

In the Hellebore, on the contrary, the ovule has its point of attachment placed near the microphyle, and we notice a cord-like swelling on one of its sides, which reaches all along it, and is called *raphe* (Fig. 219). This kind of ovule is called *anatropal*.

In the French Bean the ovule has in the same way its point of

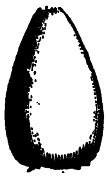


Fig. 218.—Ovule of Rhubarb.

Fig. 220.—Ovule of the Haricot.

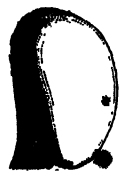


Fig. 219.—Ovule of Hellebore.

attachment placed near the microphyle, but as it has no *raphe* and is bent, it is said to be *campylotropal* (Fig. 220).

Such are three principal forms of the ovule. The second is the most common, and the first is the most rare.

The Receptacle.

The calyx, corolla, stamens, and pistils, are inserted in the extremity of the floral peduncle, which is called the *receptacle*. Its form is very variable. In the Ranunculus it is conical; the calyx, corolla, stamens, and pistil are inserted and ranked in succession on its sides, the last organs nearly at its summit. In the *Myosurus* (Fig. 221), it is so much lengthened, that it resembles a small *spike*, of which the flowers would be the carpels. As in these circumstances the stamens are inserted underneath the pistils, these stamens are said to be *hypogynous*. In the Peach (Fig. 222) and the Apricot, the receptacle has the form of a cup, at the bottom of which is the pistil, whilst the calyx

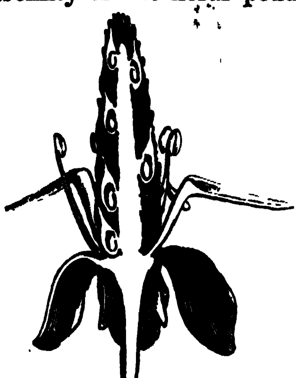


Fig. 221.—Receptacle of Myosurus.

and the stamens are inserted at the side. These last surround the pistil, and are called *perigynous*.

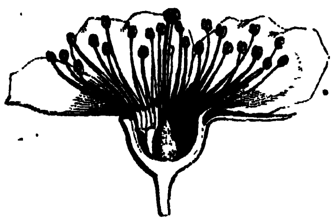


Fig. 222.—Receptacle of the Peach-blossom.

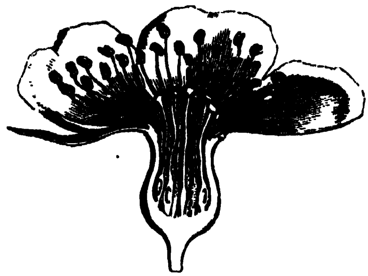


Fig. 223.—Receptacle of the Burnet Rose.

In the Rose (Fig. 223) the receptacle is hollowed out, so as to take the form of a bottle, the bottom of which is occupied by the carpels, and on the upper edges are inserted the sepals, the petals, and the stamens. These are also perigynous.

Fig. 225.—Adherent Ovary of the Fuchsia.

In all the examples we have hitherto cited, the pistil does not form any adherence with the receptacle. Also, in every case, even in that where the receptacle is hollowed out like a bottle, the ovary is *free* or *superior*. But it is not always thus. The receptacle, hollowed out like a cup, is joined rather frequently with the ovarian part of the carpels, which it encloses; and this junction is made more or less high up, so as to show every possible degree of adherence. We see this in the flower of the Saxifrage (Fig. 224), the Apple-tree, Medlar, and Myrtles; also in the flowers of the Fuchsia (Fig. 225). The ovary is then called *adherent*.

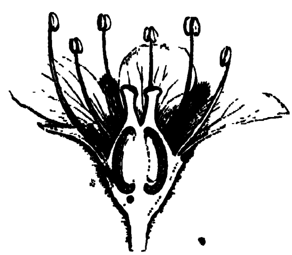


Fig. 224.—Adherent Ovary of Saxifrage.

Fig. 226.

THE FRUIT.

Flowers have but a short-lived existence; after fecundation they disappear; the ovary, rendered fruitful and enlarged in size, alone remains. The withered and dried-up fragments of the corolla strew the ground, or are carried about by the wind. But though the plant has lost much that embellished it, though it no longer possesses the brilliant ornaments which attracted observation and charmed all eyes, it still retains an interest of its own. A new decoration replaces the former one, leaving nothing to regret in the change. To the white flowers of the wild rose succeeds the young fruit, tinted with a pleasing green. The mountain ash, the medlar, and the buckthorn, in casting off delicately-tinted corolla, display their fruit, which soon changes to a bright red colour. The perfumed flowers of the orange-tree are succeeded by

the golden apples of the Hesperides; the delicate corolla of the cherry-tree is followed by the purpled globes of its fruit. The verdure of our corn fields, ripened by the summer's sun, now bend under the weight of the golden grain. We can now admire the soft down of the peach, the enormous globes of the melon-tribe, the firm and juicy pulp of the sweet-tasting plum, the nutritious substance of the legumes, the purple bloom of the grape, gilded by the autumnal sun! If flowers awake in us a feeling of happiness and joy, fruits bring with them the promise of abundance and wealth.

When fecundation is effected, life is concentrated in the ovules and in the ovary, enclosing and protecting them. These organs continue to grow, and soon present new characteristics. The ovule becomes the *seed*, the ovary becomes the *pericarp*, and the two together constitute the *fruit*. The fruit is, then, the ovary which has ripened, or *set*, as the gardeners say.

The appearance of the fruit differs according as the ovary is *free* or *adherent*. In the former case, the fruit only shows on its surface a scar on the style, and sometimes at its base the remains of the calyx, the corolla, and the androcæum. In the second, the fruit presents at its surface, and near the summit, the scars left at the insertion of the sepals, petals, and stamens. Thus it is, that an apple, a quince, or a gooseberry, all resulting from the ripening of an adherent ovary, are provided with an *eye*, which is completely wanting in the plum, the cherry, and the peach, these latter fruits resulting from the ripening of a free ovary.

"The analogy between fruits and leaves," says A. de Jussieu, "is as much shown in their nutrition as in their outward characters. Fruits, like leaves, though in a less degree, when acted upon by light, take up carbonic acid from the surrounding air, and throw off oxygen; during the night, on the contrary, they take up oxygen and throw off carbonic acid. Their life passes through the same phases; their tissues, at first soft and rich in juices, gradually solidify, and at a certain period begin to dry up, changing their green hue for some other, either that of the dead leaf, or one of the various tints, analogous to those assumed in autumn by certain leaves; the withered pericarp remaining attached to the tree, or falling to pieces, drops to the ground."

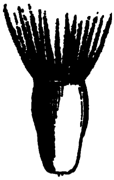


Fig. 227.—Achænium of Corn Centaury.

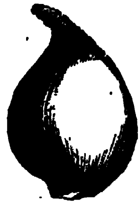


Fig. 228.—Achænium of the Ranunculus.

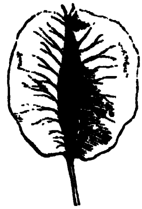


Fig. 229.—Samara of the Elm.

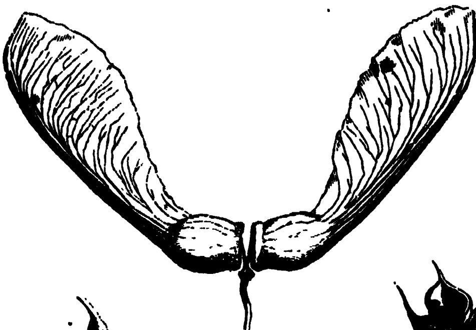


Fig. 230.—Samara of the Maple.

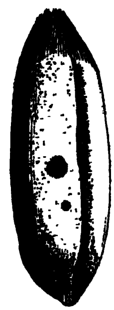


Fig. 231.—Caryopsis of Wheat.

Fig. 232.—Haricot Pod.

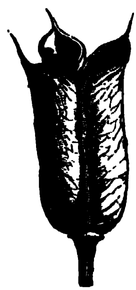


Fig. 233.—Follicle of the Aconite.

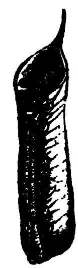


Fig. 234.—Follicle of the Aconite.

Fig. 236.—Siliqua of the Gilliflower.

Fig. 235.—Pyxidium of Henbane.

Fruits are divided into two great sections,—DRY FRUITS and FLESHY FRUITS.

DRY FRUITS.

There are some among the dry fruits which open their shell at maturity to allow the seed to escape; others, on the other hand, remain always closed up. Thence arises the division of dry fruits into *dehiscent* and *indehiscent*. The fruits of the Dandelion, Chicory, Buck-wheat, Corn-flowers (Fig. 227), and Ranunculus (Fig. 228), are *dry* and do not open. The single seed that they contain adheres only to the pericarp; this kind of fruit is called *achænium*, from α, and χαινω, "I open." The Elm has for its fruit an achænium; but being surrounded with a folded membrane, something like wings, it is called *samara*. Fig. 229 represents a section of the samara of the Elm; Fig. 230 the samara of the Maple.

The fruit of Wheat, Barley, Oats, &c., is, like the achænium, dry and indehiscent; but the single seed that it encloses adheres to the pericarp, so as to form one body with it. This fruit is called *caryopsis*, from καρυα, "wall-nut," οψις, "appearance." Fig. 231 represents the fruit, or *caryopsis* of Wheat. What a variety there is among dry fruits in their mode of opening! Some open with two valves, each carrying, on one of its edges, a row of seeds. Such are the *pods* of the Pea, Bean (Fig. 232), and other legumes. Others split up longitudinally on one side, and, in opening out, take the form of a leaf, carrying seed on its two edges; this is called a *follicle*; of this sort is the Aconite (Figs. 233, 234). Some dry fruits open in two parts by a circular horizontal chink, so that the upper part of the fruit is detached like a lid. This kind of fruit is called *pyxi-*

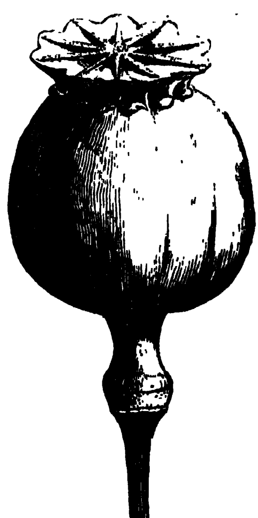


Fig. 237.—Capsule of the Poppy.

dium, from *pyxios*, "a box." We see it in the Red Pimpernel and Henbane (Fig. 235). In others, the pericarp comes away in two valves, which, by their fall, uncover a frame formed by the placenta furnished with their seed; this kind of fruit is called *siliqua*, a pod or husk; the fruit of the Gilliflower is of this sort (Fig. 236).

Can anything be more ingenious than the plan of opening in the capsule of the Poppy (Fig. 237), or of the Field-Poppy? In these instances dehiscence takes place by means of a certain number of small reflex valves disposed in a circle on the flattened top of the fruit. The seeds in it are very numerous; but, in consequence of the beautiful arrangement just mentioned, they only fall, one by one, when the capsule is bent over by the wind, thus forming a kind of natural seed-drill.

Fig. 238.—Capsule of Digitalis.

The fruit of the Foxglove (*Digitalis*), Fig. 238, which is also a capsule, opens with two valves, by the severance of the partitions in it, and each valve corresponds with a carpel; this is called *septicidal dehiscence*. The capsule of the Tulip (Fig. 239) opens with three valves, each valve corre-

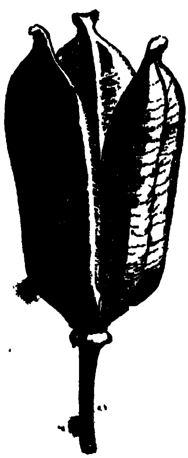


Fig. 239.—Fruit of the Tulip.

Fig. 240.—Fruit of the Sandbox-tree.

sponding with the two halves of the carpel, and has a partition in the middle. This is called *loculicidal dehiscence*.

In some plants the scattering of the seeds is assured by means rather difficult of explanation. Every one knows that by merely touching the fruit of the Balsamines their valves are suddenly thrown back, and the seeds are dispersed with great force. This peculiarity has given to one species of this order of plants the common name of Touch-me-not, and the generic name of *Impatiens*.

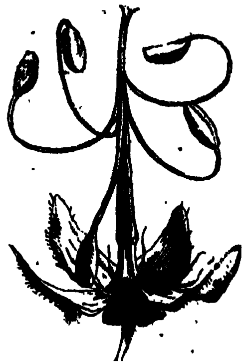


Fig. 241.—Fruit of the Geranium.

The capsullary and woody fruit of the Sandbox-tree (Fig. 240), an American tree of the order *Euphorbiaceæ*, is composed of from twelve to eighteen *cocci*, which having become dessecocated, open suddenly at the back, with two valves, and are detached from their axis with a kind of detonation. These fruits have actually been surrounded with iron wires, yet the force with which they expand has been such that the valves have been separated from each other. We will take our last example from a nearer source; the seeds of the Geranium (Fig. 241) are enclosed in little membraneous cells, which are inserted in the lower part of an axis, which is elongated and supported by a filament coming from the summit. At maturity, this filament bends in a scroll or spirally, and lifts with it the case with the seed contained inside. Thus the fruit of the Geranium, or Crane's-bill, met with in the woods and green lanes, resemble a sort of candelabra with five branches, hung from the summit of a central column.

Fleshy Fruits.

When the parenchyma of the fruit is largely developed, and it swells with juice, the fruit is said to be *fleshy*. Man derives from this kind of fruit so great a part of his nourishment, that he has exclusively styled the trees furnishing it *fruit trees*. This singularly illogical use of the term might lead to the inference that the Apricot, the Peach, the Apple, and such like trees, alone produced *fruit*. There is an obvious disagreement in this case between science and sentiment; all plants bear fruit.

Fleshy fruit is green in the first phase of its development. It then, like all the green parts of vegetables, gives out oxygen during the day, and carbonic acid in the night. But its bulk soon increases, and it receives through its peduncle the moisture and other substances indispensable to its growth. During this first period, the principles immediately soluble take their rise, and their proportions increase as the fruit is developed. These soluble bodies are—tannin, the organic acids, which vary with the fruits, malic, citric, or tartaric acid preponderating in some; sugar, gum, and pectine in others. The formation of pectine, the substance from which the *jelly* of our household delicacies is prepared, is the result of a sort of reaction of the acids on a substance insoluble in water, alcohol, and ether: a substance which almost always accompanies the cellulose in the tissue of vegetables.

Sugar proceeds from the modification of certain neutral matters, such as gum and starch. In fact, starch exists in large quantities in some green fruits, but it completely disappears at the time of ripening. It is extremely probable, therefore, that it is the starch which is transformed into sugar (*glycose*) under the influence of acids. Tannin itself, existing in almost all green fruit, is not found in the mature state, but seems also to be changed into glycose under the influence of acids.

The absence of acidity in fruit is the most curious fact attending its maturity. It has been stated that this disappearance is not owing to the saturation of acids with mineral bases, that the acids are not hidden by the sugar or mucilaginous matter existing in the ripe fruit, but that they are really destroyed during the ripening process. Tannin disappears first, and then the acids.

The moment when the tannin and acids have disappeared is that in which the fruit is most delicious; in a short time the sugar itself disappears, and the fruit becomes insipid. About the period of maturity, fruits exhale carbonic acid. They no longer disengage oxygen during the day; they *breathe*, so to speak, after the manner of animals.

Fruit at last undergoes a third modification; it becomes mellow. This new change has the effect of expelling from the fruit certain principles which belong to it. A Medlar, for example, at first very acid and astringent, loses its acid and tannin, and becomes

eatable when it becomes mellow. But the great difference established between the ripening and mellowing of fruit is, that the latter state is only manifested when the skin of the fruit, being somewhat decayed, the air has been able to penetrate the cells of the pericarp, colouring them yellow, and partly destroying them.

We need not mention here the important part played by fleshy fruit in the production of alimentary beverages. The juice of the grape, having undergone fermentation, becomes wine; the fermented juice of numerous varieties of apples and pears yield cyder and perry, and almost every known fruit yields its own peculiar product.

It is in the fleshy fruits that we can most readily distinguish the three parts constituting the pericarp, that is to say, that portion of the fruit which forms the walls of the ovary. These three parts are, tracing them from outside, the *epicarp* (ἐπί, "over," καρπός, "fruit"), an epidermal membrane varying in thickness; the *mesocarp* (μέσος, "middle," καρπός, "fruit"), constituting ordinarily the flesh and pulp of the fruit; and the *endocarp* (ἔνδον, "inside," καρπός, "fruit"), often forming the kernel, but the consistency of which varies, as we shall soon see.

As the ovary results from the physiological transformation of a leaf, and as the fruit is nothing but a ripened ovary, we may consider the epicarp and endocarp as representing the two epidermes of the leaf, and the mesocarp as the parenchyma of this original leaf. Most practical botanists only admit two classes of fleshy fruits, the *drupe* (stone fruit) and the berry. The Peach, Cherry, Plum, Medlar, and Cornel, are drupes; the Grape, Gooseberry, Apple, Orange, and Pomegranate, are berries.

All these fruits are more or less fleshy or pulpy. They are besides *indehiscent*, but there are in drupes one or more kernels, which are wanting in berries.

Let us first take a glance at the drupes. In the Peach, the Cherry, and the Plum, resulting from the ripening of a simple and superior ovary, it is easy to distinguish three parts, first, an exterior skin, more or less thick, smooth, or hairy, or covered with a waxy secretion, known as the bloom; this is the epicarp; second, a thick, pulpy, succulent flesh; this is the mesocarp:

third, a woody kernel, either smooth or furrowed with deep winding dents, constituting the solid abode and protector of the seed; this is the endocarp. Fig. 242, showing the fruit of the Cherry, and Fig. 243, giving a vertical section of the same fruit, enable us to see the interior and exterior arrangements of this drupe.

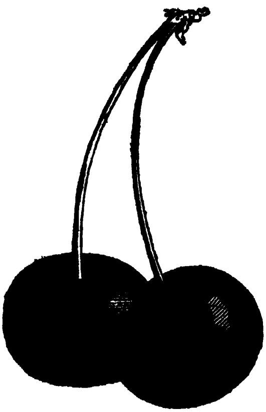


Fig. 242.—Cherries.

The fruit of the Medlar proceeding from the ripening of an inferior ovary, is composed of five compartments, and joined together by an external covering considered as an expansion of the floral receptacle. This fruit is also crowned with the sepals of the calyx. The Medlar presents five bony kernels, embedded in a pulpy mass, resulting from the transformation and fusion of all the ovarian walls except the woody endocarp, added to the expansion of the floral receptacle.

The small oblong and red fruit of the Cornel is also a drupe resulting from the ripening of an inferior and compound ovary. But the kernels are joined together in such a way that we find in the centre, one only, presenting two or three cells containing the seed.

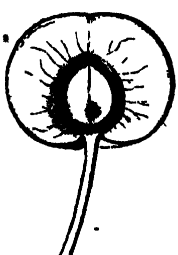


Fig. 243.—Section of Cherry.

It results from what we have said, that in the Peach, Cherry, and Plum, the eatable part proceeds exclusively from the ripening of the pericarp or the ovary walls, whilst in the Medlar or the fruit of the Cornel, the eatable part results not only from the ripening of the pericarp, but also from the transformation of the peduncle of the flower, which increases and becomes succulent.

Berries, like drupes, are fleshy and indehiscent, but without kernels. Such are the berries of the Vine or the Currant (Fig. 244), and the Gooseberry, only we must remark with regard to this latter fruit, that its eatable and pulpous part does not belong only to the pericarp, but also to the seeds, which afford a gelatinous

testa, sufficiently developed. The seeds of the Pomegranate also present a testa full of pulp.

There are other berries, the structure of which is so peculiar, that they have received special names. We will content ourselves with mentioning here the fruits of the Apple and Orange.

Fig. 244.—Bunch of Currants.

The Apple results from the ripening of an inferior and compound ovary with five cells. It is wrapped, like the fruit of the Medlar and Cornel, by an expansion of the floral receptacle. This covering becomes fleshy and succulent, like the ovary with which it is joined, of which the endocarp alone, lining the hollow of the five cells, is thin and cartilaginous. The endocarp forms that sort of scale which often sticks between the teeth when we eat an apple.

The fruit of the Orange (Fig. 245) results from the ripening of a superior and compound ovary, with several cells. The external skin, yellow coloured, dimpled, and strewn over with glands secreting an odoriferous liquid, is the epicarp. The white, spongy, and dry layer immediately under the external skin is the mesocarp. The thin membrane lining the *quarters* is the endocarp. These quarters form the same number of compartments towards their inner angle, containing seeds, and are filled with a novel and peculiar tissue, which is developed on the opposite wall of each compartment. It appears at first like slender hairs, which increase by degrees, filling up the entire cavity, which is also filled with juice, constituting ultimately a succulent parenchyma, which forms the delicious pulp of the Orange.

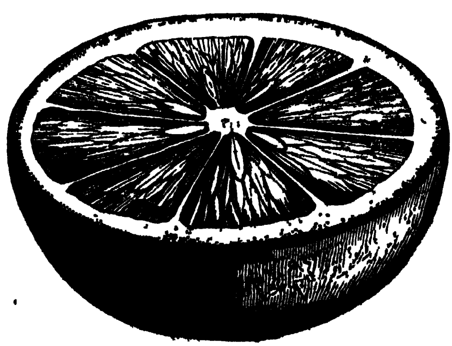


Fig. 245.—Section of an Orange.

Thus, in this much-admired fruit, the eatable part does not belong to the mesocarp, as in the Cherry or Grape; we can only say that it belongs to the pericarp as an accessory, since we reject the three principal parts constituting this integument. The eatable part is an additional tissue, so to speak, which does not exist in other fruits.

We see, by this example, how various is the structure of fruits, and what difficulties their study presents even on a limited scale. Here we must confine ourselves to a rapid sketch of some of the common fruits, whose diverse and peculiar appearance require a few words of explanation.

What constitutes the Strawberry? Is it that fleshy, succulent part essentially forming it, which is the fruit? Certainly not: the true fruits of the Strawberry (Fig. 246)—and they are very


Fig. 246.—Strawberry.

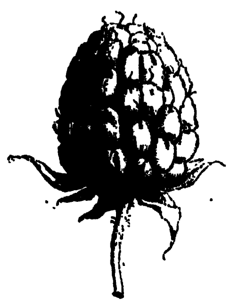


Fig. 247.—Raspberry.


Fig. 248.—Mulberry.

numerous—are those little, brownish, dry, insipid grains crunching between the teeth, which remain at the bottom of the vessel, mixed with small dark threads, when you beat up strawberries with wine. The little brownish grains are *achænia*, the small dark threads are the styles of the withered flower. What we eat, then, in the Strawberry, is the receptacle, which is gradually filled with juices; it increases in size, pushes out the little achænia, setting them into its parenchyme; it then assumes a rich colour as well as a most pleasant odour, and a sweet, aromatic, and slightly-acid flavour.

In the Raspberry, on the contrary (Fig. 247), the receptacle is dry and bears several fruits, which, far from being achænia, as in

the Strawberry, are, on the contrary, little *drupes*. The seat of the fleshy and eatable part here occupies an entirely different position.

In the Fig (Fig. 249) the eatable part is formed, as in the Strawberry, by a thick, fleshy, and succulent receptacle, of gourd-like shape. The real fruits, which the reader will have no doubt taken for the mere seeds, are achænia, and are inserted in the inside surface of the receptacle. But there is this difference between the

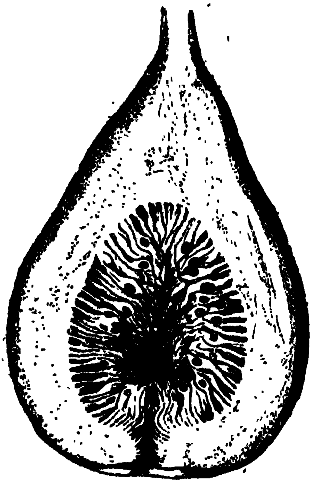


Fig. 249.—Section of Fig.

Fig. 250.—Pine-Cone.

Fig and the Strawberry, that all the fruits of the Strawberry appertain to one flower, while the fruits of the same Fig belong to different flowers.

The Mulberry (Fig. 248) is not a fleshy fruit, properly so called; it is an achænium, enclosed in a persistent calix, which has become fleshy.

The name of *cone* has been given to the fruit peculiar to a natural group of plants, the Pines, for this reason designated *Coniferæ*. The cone is a dry fruit, composed of a great number of achænia, or samaræ, hidden in the axils of hard and highly-developed bracts. Fig. 250 represents the Pine-cone.

THE SEED.

The Seed is the essential part of the fruit. It represents outwardly a system of protecting coverings, which are generally double. The various appearances presented by different seeds are owing to this covering.

Seeds are sometimes smooth, like those of Tobacco (Fig. 250) or

Fig. 251.—Striated Tobacco Seed.

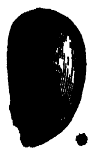


Fig. 252.—Seed of the Pear.

Fig. 253.—Fennel Seed.

Fig. 254.—Seed o Chickweed.

Fig. 255.—Seed of the Field Poppy.

the Pear (Fig. 252), sometimes wrinkled and rough-skinned, as in the Fennel (Fig. 253); or papillous or warty, as in the Chickweed (*Stellaria*), Fig. 254; honey-combed with alveolar depressions, as in the Field Poppy (Fig. 255); winged, as in the Pine (Fig. 256), or

Fig. 257.—Section of Seed of Cotton Tree.

Fig. 256.—Seed of the Pine.

Fig. 258.—Seed of Cotton Tree.

hairy, as in the Cotton Plant (Figs. 257 and 258), with hairs rising from the apex, as in Asclepias, from the base in the Willow.

The whole of the seed enveloped and protected by these integuments, is called the *kernel*, or *nucleus*.

The essential character of the Kernel is, that it contains the

embryo, that is, the germ of a new individual, a rudimentary plant in miniature, which will soon present all the characteristics of the parent plant, whose species it is to perpetuate. The embryo is composed of cells and spiral vessels; a small stem, or *stalklet;* a rudimentary descending portion, which becomes the root or *radicle;* and a rudimentary ascending axis, surmounted by a bud, or *gemmule.* Between the radicle and the gemmule, the first leaves developed are termed cotyledons: a plant having leaves like seed-lobes. Fig. 259 shows these different parts in an embryo of the Almond-tree. When the plant has only one germinating leaf, or cotyledon, as the *Ricinus* (Castor Oil-plant), (Fig. 260), Wheat-plant, Tulip, Palm, and Pond-weed (Fig. 261), we say that the embryo and the plant are *monocotyledonous;* when there are two, as in the Rose, Almond-tree (Fig. 262), and the Bean, we say that they are *dicotyledonous.*

The cotyledons of the Ricinus (Fig. 260) are very thin, and offer, on their surface, very distinct traces of veins; they resemble small leaves, while those of the Almond-tree and the Bean are thick and fleshy, and present nothing like a leaf at first sight. They have undergone deep and essential modifications, appropriate

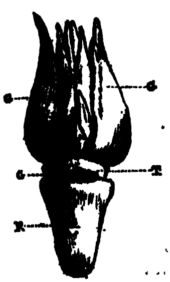


Fig. 259.—Radicle Gemmule.

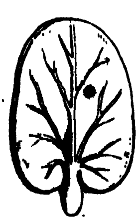


Fig. 260.—Embryo of Castor Oil-plant.

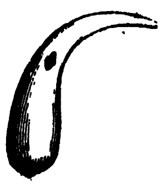


Fig. 261.—Embryo of Potamegoton.

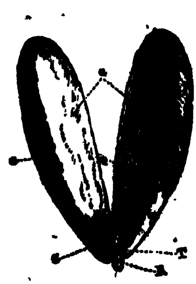


Fig. 262.—Embryo of the Almond.

to the functions they are called on to perform in the act of germination.

In a great number of cases the *kernel* is exclusively formed by the embryo, that is, the entire seed is made up of the embryo, and the integumentary covering only. But there is often developed, either around, or by the side of the embryo, an accessory and completely independent body, which is a sort of reservoir of nutritious

matter, from which the embryo draws the substances necessary for its first growth. This body is the *albumen*. When this is wanting, the cotyledons perform the functions of the nurse, nourishing the young plant, and it is to this end that they undergo the modification of which we have just spoken. Thus, in the seed of the Bean, which has no albumen, the cotyledons are much developed and full of a nutritive substance, of which the embryo takes a considerable portion. In the seed of Ricinus, which encloses a considerable portion of albumen, the cotyledons preserve the characteristics peculiar to the organs they represent; they are thin and foliaceous. The albumen varies very much in its bulk, nature, and position, in regard to the embryo, consisting of amylaceous, ligneous, gummy, and saccharine matters; with oils, resins, salts, and other heterogeneous substances. It is very considerable in Wheat (Fig. 263) and in Ivy (Fig. 264); it is reduced to a thin layer in *Ketmia Adansey*, the *Hibiscus* of modern botanists. In wheat, the embryo is placed laterally at the base of

Fig. 263.—Caryopsis of Wheat.

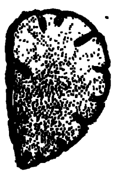


Fig. 264.—Section of Seed of the Ivy.

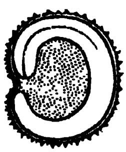


Fig. 265.—Section of the Seed of Rose Campion.

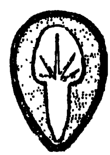


Fig. 266.—Section of the Seed of Oxalis.

the albumen, completely enclosing it in the *Nigella arvensis* (Corn Cockle), Fig. 265; it is, on the contrary, surrounded on all sides in the seed of the Wood-Sorrel (*Oxalis*), Fig. 266.

Albumen is almost exclusively formed of cellular tissue. We observe in it neither fibres nor air vessels. These cells have sometimes thin walls, as in the Ricinus, Wheat, and other cereals; sometimes their walls are very strongly thickened, as may be seen in the horny and firm tissues of the Date-stone (Fig. 267), which is only the albumen of the seed. In the albumen of Wheat and other cereals, fecula predominates in the cells. The form of the starchy grains, varying with the species, is not unimportant. If

we add to this characteristic some other considerations taken from their size, and the structure of their grains, we might detect the adulteration of flour by a simple microscopic observation, and at a mere glance.

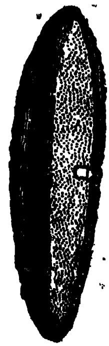


Fig. 267.—Section of the Date.

The grains in Wheat (Fig. 268) are lenticular, elliptical, and egg-shaped. It is easy to distinguish these from the grains of the Potato (Fig. 269), which are generally larger, egg-shaped also, but with punctations, surrounded by certain zones, more or less regular and defined. In Maize (Fig. 270), the starchy granules of the horny part of the albumen are polyhedral, and nearly always show a punctation placed in their centre.

In the Oat-plant, the starch grains are of several sorts. Some are simple, and their form is rounded, egg-shaped, and fusiform. Some are formed of two, three, four, or a higher, but still limited number of elements. There are some, also, compound, either spherical or egg-shaped; their diameter reaching about the five hundredth part of a millimetre, and their surface, under the microscope, resembling a mosaic of polyhedral segments. We find other substances besides starch in the thin-walled cells of the albumen of the Castor Oil-plant, and in the thick-walled cells of the albumen of the Date. Oily matter abounds there. They are filled with corpuscles of a complex structure,

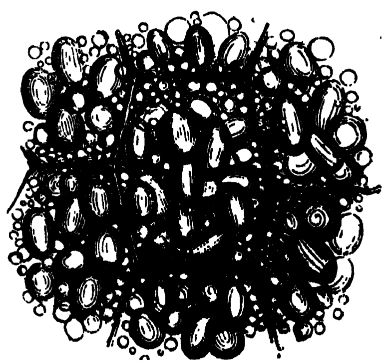


Fig. 268.—Starch Grains of Wheat.

whose chemical nature is not yet determined. These corpuscles, which in certain plants somewhat resemble grains of starch, may be termed *mealy grains*. They are more or less soluble in water, and are coloured yellow by iodine. Grains of starch are, on the contrary, insoluble in water, and are coloured blue by iodine. A very natural question here suggests itself as to the mode of transport and vitality of seeds; in short, as to the physiological phenomenon of *germination*.

Wind, running water, blocks of ice drifting in the Polar seas, the action of animals and men—that is, by cultivation—ships, merchandise, and voyages; such are the causes, more or less powerful, which effect the conveyance of seeds from one place to another. If we consider how many seeds are light, hairy, and provided with a sort of wings in their downy tufts, we can understand that the wind may be the most general and ordinary means for disseminating vegetable germs over a country. Rivers also carry away the seeds of plants to great distances. If their course runs from north to south, or the contrary way, the wandering seeds would be carried to a climate where they could not live; but if the river flows from east to west, or from west to east, the seeds thus transported would much extend the limits of the species. The currents of the sea, which skirt the coast, or extend from one country to a neighbouring one, carry the seed, so to speak, from one storing-place to another. In the latter case the seeds remain but a short time in the water, and are little altered in consequence; besides, the graduated temperature of the successive localities which they reach is favourable to their acclimatisation and to their further development. The operation of blocks of ice in the transport of seeds is not without a certain importance. Navigators of the

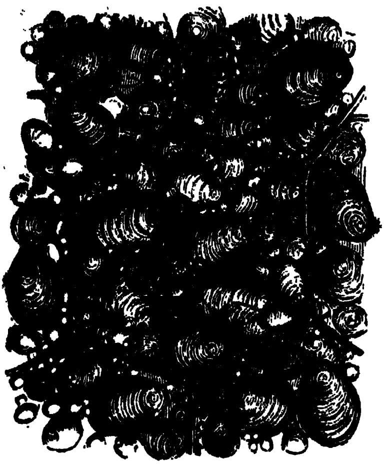


Fig. 269.—Starch Grains of the Potato.

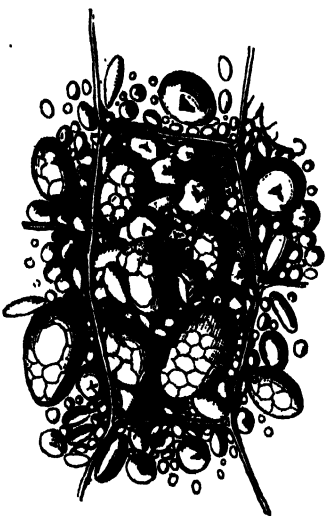


Fig. 270.—Starch Grains of Maize.

Polar seas often meet with icebergs loaded with an enormous mass of *débris*, mixed with earth and seeds. Seeds vegetate on these *débris*, and if the iceberg runs aground on some distant coast, where it melts, the seeds are deposited; they soon produce plants, which are then spread over the country by the other influences already hinted at.

The dissemination of seeds is helped, it is said, by the distant migration of granivorous birds. Yet the influence of birds appear to us of very little importance in the matter we are now considering. Most birds completely destroy seeds in the act of digestion, and it is only exceptionally that seeds can traverse their intestinal canal without being destroyed.

"Omniverous birds," says De Candolle, "often search for berries containing little hard seeds, as Grapes, Figs, Raspberries, Strawberries, Asparagus, Mistletoe, &c. Their stomach is not so destructive as that of the gallinaceous birds, and it appears that small seeds can traverse their alimentary canal without alteration. When these birds are migratory, which is often the case in temperate and northern regions, they carry the seeds to a great distance, particularly when, in the autumn, they leave northern climates to seek the sunny south, for at this season ripe fruits abound in the country. Thrushes, many of which change their country either in Europe or in America, can thus transport some sorts. When they eat too large a quantity of stone fruit, they digest them badly, and spread the seed with the kernels. There is an observation of Linnæus which assures us that the lark scatters a great many seeds in the fields."

By the same process, namely, by the imperfect digestion of seeds which have served them for nourishment, certain quadrupeds, particularly the herbivorous, are able to transport seeds from one part of the country to another. This happens in the case of the reindeer, an animal living in herds in the plains of Siberia, which, at a certain period, migrate in large numbers. Such also is the part played by the herds of cattle driven often to great distances in our European climates, and in general in all civilised countries.

The action of men in the dissemination of vegetable seeds is shown in a thousand ways. We will borrow from M. Alphonse de Candolle some interesting remarks on this subject.

"The first colonies which were sprinkled over each continent," says this learned botanist, "probably carried with them several species of useful plants, and especially some of those seeds which get attached to clothes and to domestic animals, and which will grow easily in the neighbourhood of dwellings, near dung hills, burnt ground, and rubbish heaps. The scantier the population, and the more foreign it is to the arts of civilisation, the more insignificant become these primary seed-carryings. When the population becomes denser and more civilised, when agriculture begins and extends its rule, then the occasions are multiplied for the transport of seeds. A hunting or pastoral people, no doubt, traverse a vast extent of country, but an agricultural people prepare ground fit for the reception of new species, and bring the seed for their fields from more or less distant countries, introducing with it different plants, many of which naturally grow wild. In short, war has created vast empires, and compelled men to make numerous journeys; navigation has extended itself, new countries have been brought in communication with the old, agriculture has exported its products, and horticulture has stocked our gardens with thousands of foreign species. By all these means the transport of seeds has become increasingly great, and an influence has been exercised quite preponderating over natural causes."

Commerce, which carries in its ships the products of the trading of nations, furnishing Europe with the produce of the New World and returning to it European productions in exchange, is sometimes an indirect agent in the transport of vegetable seeds. The wool from the sheep of Buenos Ayres, Mexico, or La Plata, when it is brought into Europe, carries entangled in the fleeces the seed and remnants of plants in those countries. When the fleeces arrive in Europe, they are cleaned, beaten, and washed, and the seeds fall off; they may then shoot in this new soil, and transplant into our climate the vegetable species from regions across the Atlantic. At the edge of the river Lez, near Montpellier, at a place called Port Juvenal, the American wools are received to be cleaned and purified, and then sold to the cloth-makers of Lodéve. Seeds of American plants, which have been brought in these fleeces, have actually sprung up in the environs of Montpellier, so much so that all the celebrated botanists of Montpellier, such as

De Candolle, Dunal, Delille, Gordon, and Ch. Martins, have examined and studied in this small place in southern France many vegetable species belonging to the Flora of Buenos Ayres and Mexico.

How long does the power of germination last in a seed? Some seeds rapidly lose their latent life, or, which comes to the same thing, the faculty of germination. There are others which, placed in the same circumstances, preserve their vitality for ages.

The seeds of most plants of the Leguminous tribe will germinate many years after they are gathered. Every one has heard that the seeds of Beans, taken lately from the herbal collection of Tournefort, a celebrated botanist in the seventeenth century, germinated perfectly. In 1824 there were sown, at the Jardin des Plantes of Paris, some seeds of the *Mimosa pudica* which had been gathered at St. Domingo in 1738.

If seeds are placed under special conditions, sheltered from atmospheric agency, in ground more or less dry and heaped up, for example, in tombs or catacombs, their vitality may be preserved for a prodigious time. It is a recognised fact that, after the destruction of a forest, we see a new sort of growth appear on the ground the forest used to occupy. It has been admitted, to explain this fact, that seeds of trees, buried in the ground while the forest existed, were preserved in the soil, with their life suspended during a considerable number of years; that, then awaking from their lethargic sleep, they have been developed under the influence of new conditions favourable to their germination. This hypothesis is plausible enough in some cases, yet as no scientific experiment has been made on the subject, it might happen that in this case the second germination of trees was owing to the transport of foreign seeds, which germinated as soon as the soil had become free, and restored to light.

Almost marvellous examples are quoted of the longevity of seeds. Dr. Lindley, the learned botanist, asserts that some Raspberry seeds which were found in a Celtic tomb, and which numbered about seventeen hundred years of existence, had germinated perfectly, and produced Raspberry plants, which still exist in the Horticultural Society's Gardens in London. M. Ch. Desmoulins asserts that the seeds of the Lucerne, Cornflower, and Heliotrope

found in some Roman tombs, dating from the second or third century of the Christian era, have not only germinated, but produced individual plants, which have in due course flowered and borne fruit.

We must be on our guard against such prodigies as these. Although nature, as has been said, performs wonders, we must only believe in facts rigorously established, in order to avoid the mystifications and tricks which the malignity of the vulgar loves to play upon the infallibility of *savants*.

We must not forget to speak of those wonderful seeds of wheat found in the tombs of ancient Egypt. It is now acknowledged that in this affair some one must have abused the confidence and credulity of the travellers. A variety of Wheat called Mummy Wheat is common, it is true, among farmers; but no authentic fact justifies its name. Though there is, as we have just seen, so great a difference in seeds as to the duration of their vitality, the difference is not less as regards the time necessary for their germination. Some seeds, as Garden-cress, Poppy, and the cereals, germinate in a few days. Others, as those of the Peach, Almond-tree, Nut-tree, and Rose-tree, require one or even two years before they "come up." This difference is owing partly to the size of the seeds, their hardness, and the woody nature of their integuments; it is due also to the presence of a kernel round the seed.

There are some seeds which seem in such a hurry, so to speak, to develop themselves, that they even germinate in the fruit enclosing them. This very often happens among some sorts of Lemon-trees, and certain of the Cucumber family. The embryo of the Mangrove, a tree inhabiting swamps, mouths of rivers, and sea-beaches in the equinoctial regions of America, is developed inside the fruit, still hanging on the branches; and there may often be seen hanging from it a root more than a foot in length.

PHENOMENA OF LIFE IN PLANTS.

FECUNDATION—GERMINATION.

The consideration we have given to the subject of the flower and fruit enables us now to enter on two great questions in vegetable physiology. Firstly, the influence of the stamens on the pistil, or *fecundation* in plants; secondly, *germination.*

FECUNDATION.

Of all the phenomena in the life of plants, there is none more interesting or more remarkable in itself than fecundation. When the existence of sexual differences in vegetables was first propounded, the discovery produced general astonishment. If the most convincing proofs had not established it, if the commonest observation had not allowed every one to verify its reality, it would, certainly, have been classed among the most singular inventions that ever issued from a poet's imagination. But the proofs were convincing. The demonstration of the existence of sexual organs in vegetables became a brilliant and unexpected fact, exhibiting a wonderful analogy between animals and plants; filling up in part the gulf which had hitherto existed between the two great classes of organic beings, yielding an inexhaustible fund of reflection and comparison to naturalists and thinking men.

The ancients had very vague ideas on this subject. Yet we learn from Herodotus that, in his time, the Babylonians already distinguished two sorts of *Date Palms;* they sprinkled the pollen of one on the flower of the other in order to perfect the production of the fruit of that valuable tree.

Césalpin, an Italian philosopher, physician, and naturalist, who, in the 16th century, was professor of medicine and botany at Pisa, remarked that certain sets of *Mercurialis* and *Hemp* remained sterile, while others were productive. He considered the first as the male sets and the second as the female. In the 17th century,

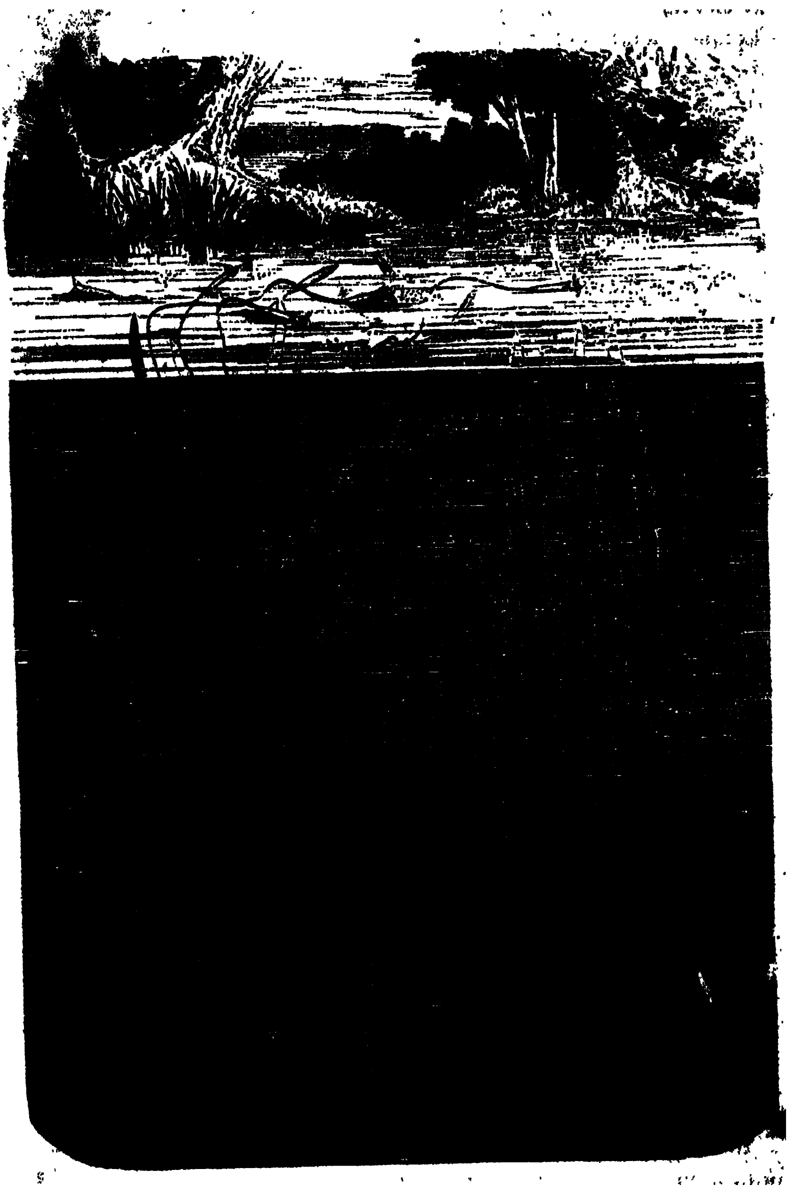


Fig. 271.—Vallisneria Spiralis.

Nehemiah Grew, a learned English fellow of the Royal Society of London, who published in 1682 an *Anatomy of Plants*, gave all Jacques Camerarius, a German botanist, born at Tubingen, showed the precise use of the two essential parts of the flower, and the part that each plays in producing the fecundation of germs. In a letter now become celebrated, *De sexu plantarum*, published in 1694, Camerarius completely proved the great fact of the existence of the sexes in plants just as in animals. This discovery made an impression on the minds of naturalists; it was, in fact, one of the most striking victories which natural science had obtained.

After the labours of Camerarius, the existence of sexes in vegetables was generally admitted. Tournefort was incredulous, but Sebastien Vaillant, one of his most brilliant pupils, publicly professed in the Jardin des Plantes at Paris the theory of separate sexes in plants. In 1735 the celebrated Linnæus rendered it popular by basing on the sexual characteristics of vegetables his vast and admirable system of classification, the importance of which we shall appreciate further on.

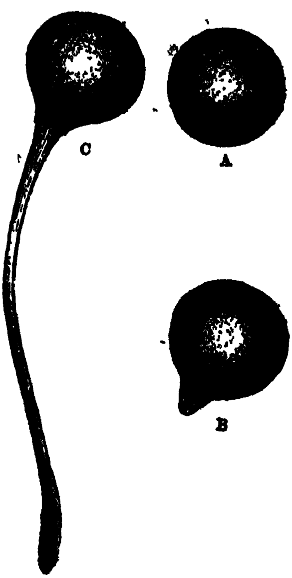


Fig. 273.—Throwing out the Pollen Tube.

The pollen having been recognised as the matter which fecundates the ovary, the next question was to discover in what manner the grains of pollen produced the fecundation of the vegetable germ. It was at first thought that the grains of pollen simply opened on the stigma, and that the granules which they contained, being absorbed by the stigma, went to form the embryo, or concurred in its formation. It was the most natural opinion to form *à priori*, yet observation has since proved that a much more complicated process takes place.

In 1823 Amici, an Italian natural philosopher, while observing the African *Purslane*-tree, perceived that the grains of pollen, far

[illegible]ing, as was thought, on the stigma, in order to pour out the [illegible]ating matter, changed by degrees into a sort of membran[illegible]ube, which he called the *pollen-tubes*, as represented in [illegible] Fig. 272, which shows the successive stages through which the pollen passes when the *pollen-tube* is thrown out at the moment of fecundation.

In 1827 the celebrated botanist, M. A. Brongniart, in his researches on this subject, perceived that the same fact recorded by Amici occurred in numerous plants; he observed also that the pollen-tubes generally penetrated more or less into the style. He instanced the *Datura* as one of those plants in which the action of the pollen on the stigma is very observable. "These tubular sacs," he says, "are for the most part already filled with granules, and easily distinguished from the tissue of the stigma by their brownish colour and opacity. I could not find a better comparison for one of these stigmata," he adds, "than a pincushion entirely filled with pins stuck into it up to the head."

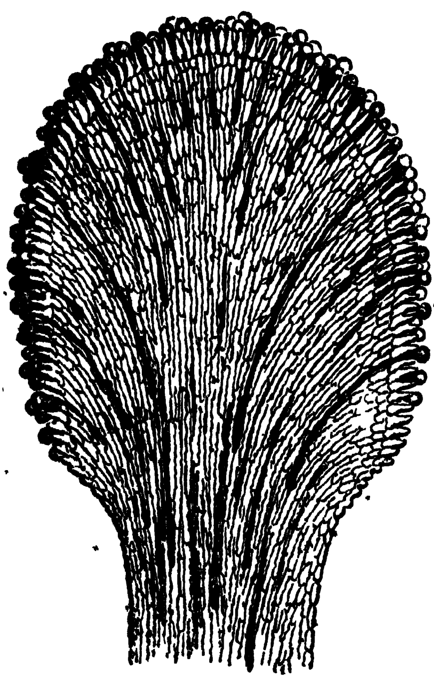


Fig. 273.—Vertical Section of the Pollen Tube of Datura.

Fig. 273 represents, according to the account of M. Brongniart, a vertical section of a stigma of *Datura* fecundated and furrowed with pollen tubes through all its thickness. Such is the appearance which the stigma of the *Datura* presents when strongly magnified.

Fig. 274 is intended to show the same arrangement in the same plant, but still more strongly magnified. The grains of pollen

and the pollen tube are here still more enlarged, the better to show the structure and passage of the tube through the substance of stigma.

In order to understand this curious organic peculiarity, Fi

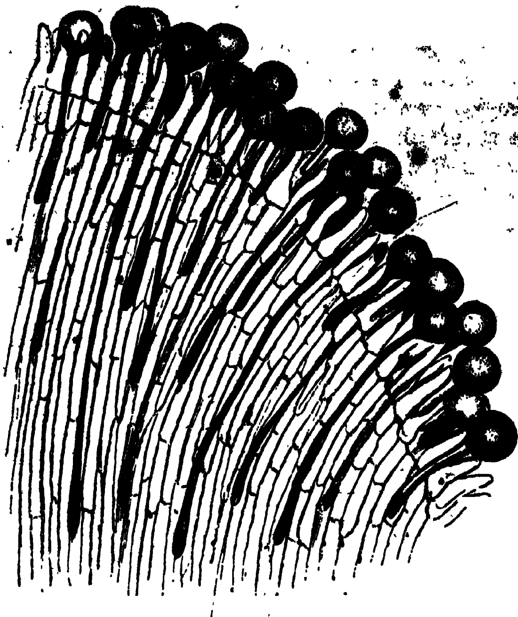


Fig. 274.—Conducting Tissue in Datura Magnified.

represents a similar stigma of the *Datura* seen externally, and resembling, as M. Brongniart says, a pincushion full of pins. But such is the incessant progress of science, that in our days these early observations of M. A. Brongniart have been carried much further, and recent investigations show still more clearly the system of progression in the pollen-tube.

This tube, as M. Brongniart has shown, elongates itself by a most remarkable vegetative process, insinuating itself into the ...es of the cellular tissue, which has been designated from ...e the conducting tissue, and that doubtless by which it is

nourished. Occupying the centre of the style, this tube traverses its whole length, entering into the ovary, and is there brought in

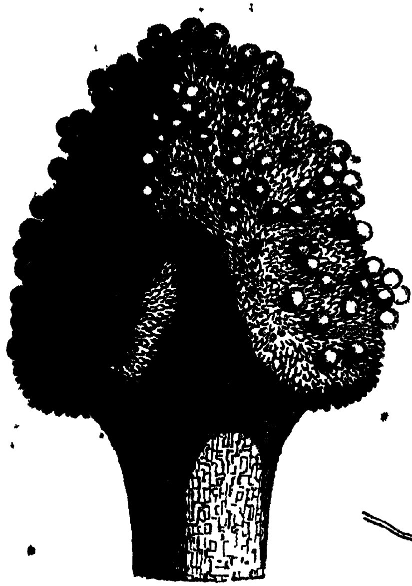


Fig. 275.—Stigma of Datura covered with Pollen.

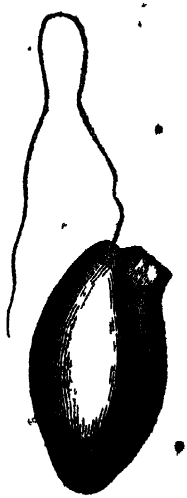


Fig. 276.—The Ovule.

A

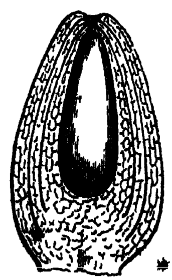


Fig. 277.—Section of the Ovule of Polygonum before Fecundation.

B

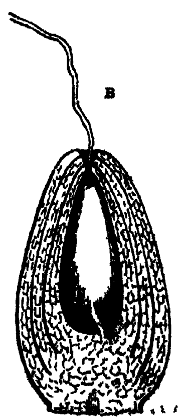


Fig. 278.—After Fecundation.

contact with the ovules, penetrating by their micropylic perforations.

Fig. 279 is a section of the stigma, style, and ovary, and is intended to point out the long course followed by the pollen-tubes in penetrating from the stigma to the interior of the ovary, where each of them comes in contact with the ovules.

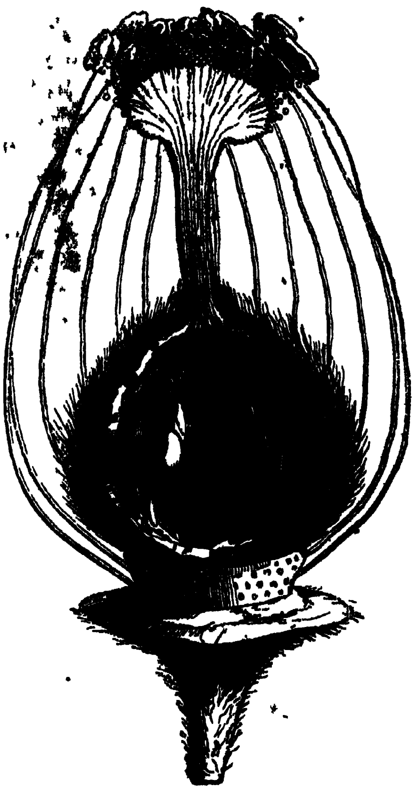


Fig. 279.—Fecundation of the Ovule.

One of these ovules is represented in Fig. 276, taken singly and magnified, to show this phenomenon more clearly. The ovule here represented is that of *viola tricolor*. The extremity of the pollen-tube, in contact with the summit of the ovule, proceeds to place itself in still nearer connexion with one of the constituting cells of this nucleus, now excessively developed, in which state it bears the name of the *embryo-sac*, because there the embryo is fully developed and ready to burst. The same organ is represented, at the moment of fecundation, in Fig. 277. Here an internal section of the ovule of the *Polygonum* is given, both before and after fecundation; A is the ovule before fecundation, B, Fig. 278, the same organ after it. We see on the fecundated ovule B, the commencement of the formation of the *embryo-sac*, at the terminating point of the pollen-tube.

About the year 1837, two German botanists, MM. Schleiden and Horkel, announced that the vegetable embryo pre-exists as a

germ within the grain of pollen, and that it is formed of the end of the pollen-tube itself, while this extremity is lodged in the embryonic sac, whence it is driven back before it.

This theory, which reproduced, and seemed to take for granted, in the vegetable kingdom the celebrated hypothesis on the *enclosure of germs* put forth by Buffon for the animal kingdom, made much noise among the learned in Europe. It was supported by the personal observations of many of our best botanists; but it could not long resist the multiplied investigations that the importance of the subject called forth on all sides.

MM. Amici, Mohl, Uuger, and Hoffmeister soon demonstrated that, in fact, when the pollen tube had once reached the embryo-sac, it remained there, attached by its external wall, and that there its functions ended with its life; whilst a little vesicle plunged in the mucilaginous juice with which the embryo-sac is filled, absorbs by endosmose the fertilising elements which the pollen-tube has doubtless passed through its constituting membrane, and that this element is then developed so as to form the embryo.

Schleiden's theory of the pre-existence of vegetable germs received its final blow, when, in 1849, M. Tulasne, one of the ablest of French anatomists, published his magnificent studies on vegetable embryogeny. M. Tulasne had always observed that the obtuse extremity of the pollen-tube was brought close to the membrane of the sac, strongly adhering there without causing any perceptible depression. At some distance from the point of contact, there was developed, on the membrane of the sac, a vesicle with a circular base, at first like a blister, which by cellular growth was soon transformed into the embryo. Fig. 280 represents the result of M. Tulasne's observations, and the manner in which the extremity of the pollen-tube is introduced into the *nucleus*. Fig. 282 is an internal section of the same organ, showing the formation of the vesicle about to become the embryo, and Fig. 281 shows this vesicle now become a small globe of parenchymatous tissue, a sort of rough sketch of the embryo. The embryo thus formed may acquire considerable development, and absorb for its own use all the soft matter contained in the embryo-sac; or it may be limited in size, and this soft matter, becoming a permanent and cellular

tissue, which constitutes itself an accessory but important part of the plant, which is known by the name of *albumen*.

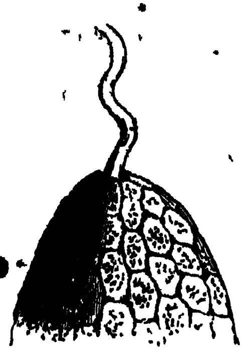


Fig. 280.—Pollen Tube entering the Pericarp.

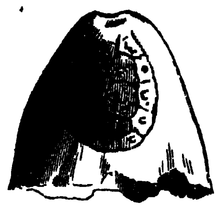


Fig. 281.—Formation of the Embryo.

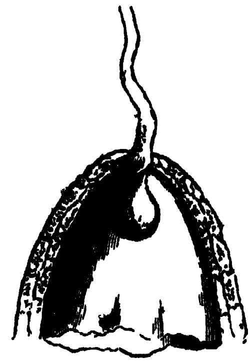


Fig. 282.—Developing within the Pericarp.

We have now rapidly set forth the functions of the pollen and the ovule in the great phenomenon which secures the perpetuity of the species; but in this rapid glance at some of the most secret mysteries of vegetable fecundation, we have stated the facts without occupying ourselves with any of the external circumstances, that is to say, the influences acting from without, which prepare for it, and which determine and favour it. We now enter into some details on this subject, and of some of the phenomena accompanying fecundation.

In a great number of hermaphrodite flowers, the stamens at the period of fecundation elevate their anthers higher than the stigma; so that the pollen falls naturally upon it at the moment of the opening of the anthers. In other flowers, the stamens carry their anthers lower than the stigma, but the flower is habitually inclined or suspended, as in the Fuchsia; the deposition of the pollen on the stigma is then made without any obstacle.

When the stamens and pistils are not close to one another, nature sets the necessary means to work to promote their near approach. Thus, we observe in different plants some very curious and varied movements in the stamens, at the period of fecundation. In the Nettle, the Mulberry, and the Pellitory, for instance, the

filaments of the stamens are bent backwards on themselves, under the pressure of the floral envelope; but as soon as full bloom takes place the filaments unroll and the pollen is projected to a distance of thirty or forty inches or more. This movement is simply the result of the elasticity of the organs. In the Rue, at the moment of fecundation, each of the numerous stamens constituting the andracæum, bends itself over the stigma, deposits the pollen there, and resumes its former position. Here is an individual and really spontaneous movement.

In the Passion-flower the styles are at first erect, but at the moment of the opening of the anthers, they are observed to curve downwards, and lower themselves towards the stamens, and then to rise up and resume their former position.

In the flower of the Barberry, if a stamen is touched with the point of a pin, it is brought close to the pistil by a sudden movement, and then, in a little time, resumes its former position; and this it will do again if fresh irritation is produced. A phenomenon of irritability is shown here, which does not exist in the other cases just specified.

The hairs which cover the styles of the Campanula show a very singular property. They fold back on themselves, like the finger of a glove, the end of which is pushed inwards, and they draw with them into this retreat the grains of pollen, the fall of which they thus determine.

In a pretty little plant of New Holland, known under the name *Leschenanthia*, the stigma is in the form of a cup, and it is edged with rather long hairs. At the moment of the anthers opening part of the pollen falls into the cup of the stigma, which contracts in order to grasp them, whilst the hairs approach each other so as to prevent the exit of the fertilising dust.

In the facts we have just pointed out, the organs themselves act to produce the fecundation of the flower. But this physiological action is often facilitated by the concurrence of exterior agents. The wind has power to transport the pollen to a certain distance and thus favours the fecundation of the flowers in *monœcious diæcious*, or *polygamous* plants. Insects, while flitting from flower to flower, often become the active instruments of vegetable fecundation.

In the *Orchidaceæ*, in which the structure of the pollen is very peculiar, the intervention of insects appears favourable, but not indispensable, to fecundation.

When the doctrine of sexual organs in vegetables was first made public by Linnæus, it was disputed by many. Conrad Sprengel, a patient observer, watched during many long hours for the instant when an insect, settling on a flower, should suck out its sweet-smelling juices and deposit the pollen grains on the stigma of the flower. Sprengel succeeded in this way in verifying a natural fact, interesting without doubt, but it was no argument against the doctrine of Linnæus; nor did the work he published in which all the arguments against the sexual system in plants were reproduced, at all change the current of the new ideas.

In certain climates the *humming-birds* are useful auxiliaries in the fecundation of flowers. The hand of man, also, frequently intervenes in practising artificial fecundation—bringing in this way the most convincing of all arguments in favour of the doctrine. We may instance as an example the fecundation of the Date-tree, which is practised in Algeria and all over the East, as related by a botanist who has studied the subject on the spot:—"Towards the month of April," says M. Cosson, "the Date-tree begins to flower, and then artificial fecundation is practised extensively. The male spathes are opened at the time when a sort of crackling is produced under the finger, which indicates that the pollen of the flowers in the cluster is sufficiently developed, yet has not escaped from the anthers; the cluster is then divided into fragments, each containing seven or eight blooms. Having placed the fragments in the hood of his *burnous*, the workman climbs with marvellous agility to the summit of the female tree, supporting himself by a loop of cord passed round his loins, and at the same time round the trunk of the tree. He glides with great address between the stalks of the leaves, the strong and sharp thorns of which render the operation rather dangerous; and having split open the spathe with a knife, he slips in one of the fragments, which he interlaces with the branches of the female cluster, the fecundation of which is now made certain."

Another phenomenon sometimes exhibits itself at the time of flowering, which bears an intimate relation to fecundation; this is the

production of heat. M. Ad. Brongniart has made some experiments on this subject which have become famous. At the time of opening, the flowers of the sweet-smelling Colocasia presented to this observer an increase of temperature that might almost be compared to an attack of daily fever. These attacks were repeated for six following days with a considerable intensity, and almost at the same hour; for it was between three and six in the afternoon that this increase of temperature reached its maximum. Analogous phenomena have been noticed at the time of fecundation in the flowers of our common Arum (*Arum vulgare*), of the splendid *Victoria Regia*, the Magnolia, and some other plants.

It is impossible to conclude our remarks on the fecundation of plants without instancing the aquatic plant known as *Vallisneria spiralis*, which has long been the admiration of naturalists, while poets have sung its praises. The *Vallisneria* is a diœcious plant; that is, it has male and female individuals existing separately, in the tranquil waters of some countries in central Europe, principally France and Italy (Fig. 271). In the female plant the peduncle of the flower is very long, having the form of a spiral twisted thread-like filament. A few days before fecundation the spiral turns untwist themselves, and the peduncle lengthens, until the female flower terminating it reaches the surface of the water, and floats on its surface. The male plant presents, on the contrary, a very short peduncle, which is not capable of any extension; it bears a multitude of little flowers, provided with stamens only, and enveloped by a closed transparent spathe. At the time of full bloom the spathe is torn, the peduncle of the male flower severs itself towards its upper part, and the flowers separated from the stalk rise: all shut up, like very small white pearls; they float on the surface of the water, and proceed to open near the female flower, which seems to wait for them. When fecundation has been effected, the peduncle of the female flower contracts; it brings together its spiral turns, and carries its ovary to the bottom of the water, in order to ripen its seed.

This is a phenomenon which has always excited the just admiration of naturalists and observers of every class. I was initiated into the first elements of natural science, at the Lyceum of my native town by M. Joly, now professor of the Faculty of Science

at Toulouse, a young professor then, who excelled in inspiring his pupils with a taste for this sort of study. The wonderful incidents attending the nuptials of the *Vallisneria spiralis*, or still more the marvellous evolutions of the Nautilus floating on the sea, or disappearing in its depths at its own pleasure, were the favourite texts for the discourses of M. Joly during our botanical and geological excursions round Montpelier, in the flower-decked wood of La Valette, or on the volcanic summit of Monferier. Thirty years have elapsed since those happy youthful days, and the recollection is just as vivid, just as present to my mind as if I still heard the burning words of our then young teacher ringing in my ears, telling us, under our radiant skies, all about the wonders of nature, and the power of God.

GERMINATION.

In order that a seed should germinate, three conditions are requisite—heat, air, and moisture; temperature, varying in different species, must not be much less than 10° or 15° (centigrade), and it must not reach higher than 40° or 45°.

Moisture penetrating the seed beneath the ground softens it, swells all its parts, and allows their intimate evolution.

Air is also as indispensable to the germination of seeds as it is to animal life. Seeds which are buried too deeply in the ground, and are thus cut off from the air, will never germinate.

What, then, is the important part that atmospheric air performs in the act of germination? It is just the same as that which it fulfils in the respiration of animals. Air acts on the seed by means of its oxygen. The germinating seed, like the animal, breathes out carbonic acid. It takes up carbon into its own substance, and the carbon combines with the oxygen of the air to form carbonic acid; but from the instant when, by the progress of germination, the young plant has produced small green leaves, the chemical phenomenon is, so to speak, reversed. In the daytime, and under the influence of light, the young plant absorbs carbonic acid from the air, and replaces it with oxygen; its respiration takes place just as we stated when speaking of this physiological function in the green-coloured portion of vegetables.

We will now follow the series of phenomena presented to the observer by the germination of a seed.

The first apparent effect of germination is the swelling of the seed, and the softening of the coverings that envelope it. If the seed is enclosed in albumen, the embryo, which is in contact with the albumen, either over its whole surface, or the greater part of it, absorbs the nutritive matters which it contains, and increases in size in the same proportion as the albumen gets less, being developed at the expense of the substance stored up for this end by a provident nature. If the seed is destitute of albumen, and the embryo at the time of dissemination fills up the whole cavity of the seed, then the cotyledons—which are farinaceous in the Pea, or fleshy in the Nut or Cole-seed—which form the greater portion of the embryonic mass, will perform the part of albumen, as regards the rest of the embryo. Fig. 283 represents the first effort of germination in the Bean, a plant not provided with albumen.

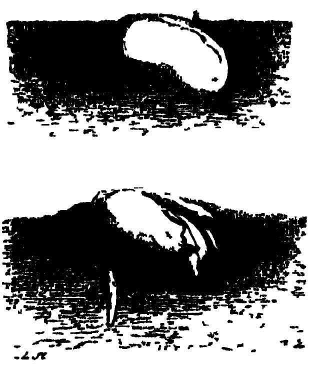


Fig. 283.—Haricot Bean germinating.

It was long a mystery how the starch of which the albumen of Wheat is almost entirely constituted, can be absorbed by the young embryo, since the radicles of plants absorb soluble matters only, and starch is completely insoluble in cold water. But the interesting discovery has been lately made, that the insoluble starch becomes soluble under the influence of an energetic agent, which is developed near the germs at the time of the seed germinating; this dissolving agent has received the name of *diastase.* The starchy matter transformed by diastase into a soluble substance, bears the name of *destrin.* Destrin is modified in its turn under the influence of diastase, and becomes sugar. We shall be right, then, in saying, that the first nourishment of the young plant is sugared water.

Efforts have been made to discover if a grain of starch, while being transformed into destrin, shows any visible trace of so com-

plete a molecular change; whether it disappeared suddenly under the action of diastase, or is only gradually changed into a somewhat similar substance, so that one could follow out with the microscope all the phases of this change. It has been proved that this change is only brought about by successive steps, and we are enabled to follow the progress of this alteration in the germination of several plants.

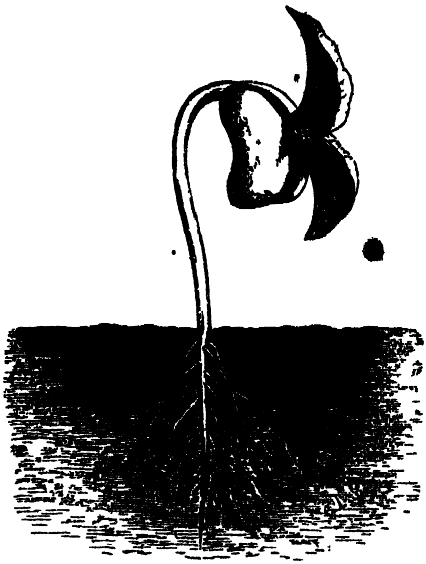


Fig. 284.—Germination of the Spanish Bean.

To return to the evolution of the embryo. However thus nourished and strengthened, either at the expense of the albumen, or of its own cotyledons, the embryo quickly presses the integuments covering it on all sides, which, in the end, are broken, thus giving it a passage through. This rupture takes place sometimes in an irregular manner, as in the Spanish

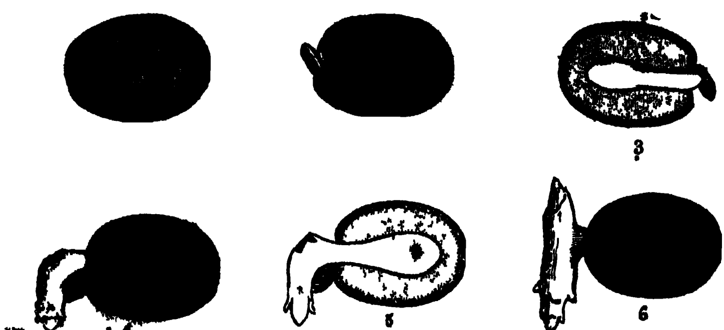


Fig. 285.—Germinating of the Sugar Cane

and other Beans (Fig. 284); sometimes in a very regular manner, as in the Virginian Spider-wort, the Date, and the

Flowering Cane. In the last case the embryo appears outside, through an opening very regularly cut out in the integument covering the seed. This opening is hidden at first by a sort of disc, or lid, which the little root of the embryo lifts up, in order to make its way out and bury itself in the ground.

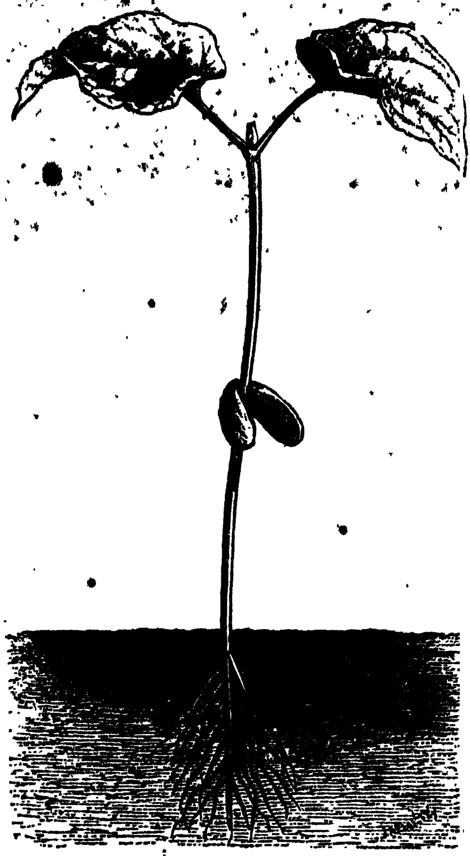


Fig. 286.—Germination of a seed without albumen, showing the Cotyledons which rise on the stem.

Fig. 285 shows the successive stages through which a germinating seed of the Sugar Cane passes. The little lid is lifted up and cast aside (1); the cotyledon is developed, elongated horizontally, and the radicle pushes out (2); the radicle is sometimes pointed to the ground (3); the gemmule, or bud, sallies out from the opening of the cotyledon, which is transformed into a sheath (4); the radicle is increased in size, and the rudiment of the stalklet appears (5); the stalklet is formed (6). The seeds of most of the monocotyledonous plants are provided with albumen, and at the time of germination the cotyledonous limb remains shut up in the seed, as we see in the Palms, Flowering Cane, and Virginian Spider-wort.

PART II.

CLASSIFICATION OF PLANTS.

Every plant which grows on the surface of the earth or in the waters constitutes a distinct individuality. The careful examination and comparison of a certain number of these individuals of the Vegetable World will lead to the admission that many are quite identical in some of their characteristics, while others possess no character in common. Examine the individual plants, for instance, which compose a field of oats; in each the root, the stem, the flowers, the fruit, present the same identical characters. The seed of any one whatever of these plants will yield other plants like those of the field. Every individual in the field belongs to the same species—to the species *Avena*.

The species, then, is a collection of all the individuals which resemble each other, and which will reproduce other individuals like themselves.

These species may present, as the result of diverse influences, such as change of climate or cultivation, differences more or less marked—tendencies more or less tenacious in resisting efforts to withdraw them from the original type. To these, according to their importance, botanists give the name of *varieties* and *sub-varieties*. The Wheat-plant, the Vine, the Pear, the Apple, and most of our cultivated legumes, all yield, under the influence of culture extending over a long series of years, plants altogether different from the original in their exterior; but they preserve, one and all, the essential characters of the species. They are *varieties* of the Wheat-plant, of the Vine, of the Pear, of the Apple.

The assemblage of a certain number of distinct species present-

ing the same general characteristics, the same disposition of organs, the same structure of flower and fruit, constitute a group to which the name of *genus* is applied. *Rosa Canina*, *R. Villosa*, and *R. Sabini* are three different species of the same group—the genus *Rosa*. The words *oak*, *poplar*, *barley*, are collective common names, which served, long before Natural Science existed, to designate a certain group of plants. These are true generic names of popular creation, which botanists have accepted because they were the result of exact observation. "A man of observant eye and quick intelligence," says Pyramus de Candolle, "would observe certain groups in the vegetable kingdom which we call genera, before discerning the species."

The germs of Botanical Science are to be sought for in the rudimentary state in very remote antiquity. In the sacred writings we meet with constant allusions to the vegetable world. The cultivators of the science among the early Greeks and Romans were not Botanists, but *Rhizotomæ*, or root-cutters, since they directed their attention to the roots in search of medicinal properties. Aristotle of Stagira, who lived four hundred years before our era, may be regarded as the founder of botany; Mithridates, several Greek kings, and the younger Juba, King of Mauritania, were among its cultivators. They established Botanic Gardens, some probably from love of the science, others of them in order to cultivate the deadly plants from which poisonous juices were obtained. Nicander of Colophon, Cato, Varro Columella, Virgil, Pedacius, Diascorides of Silicia, and lastly, the elder Pliny, all dwell upon the wonders of vegetation; and war, notwithstanding its desolating tendencies, was made to promote the interests of science.

To the Arabians of the twelfth century we are next indebted for our knowledge of botany. After them the darkness of the Middle Ages set in, and it is only since the illustrious Venetian, Marco Polo, came to examine and describe the wonders of the East, that the darkness has been dispelled. He examined the treasures of Asia and the East Coast of Africa, described many plants of India and the Indian Ocean, and from his day to the present our knowledge of the names of plants, as well as of their structure and physiology, has been continually on the increase.

The science of botany, as now understood, cannot be held, however, to date farther back than two centuries. In the year 1682 Nehemiah Grew, the Secretary to the Society of London, afterwards the Royal Society, published his "Anatomy of Plants." A few years later the French botanist Tournefort, then Professor of

Fig. 287.—Tournefort.

Botany at the Jardin des Plants, published his "Elements o Botany," being the first attempt to define the exact limits o genera in vegetables. Most of the genera established by Tourne fort remain, proving the correctness of the formula from which h deduced their common characters. Tournefort succeeded to a larg extent in unravelling the chaos into which the science of botan

had been plunged from the days of Theophrastus and Dioscorides. Separating genera and species according to their characteristics, he described no less than 698 genera, and 6,146 species. He announced, at the same time, a system for the classification of plants, eminently attractive, especially if we connect it with the times in which it appeared. The French botanist directed the attention of observers, probably for the first time, to those parts of plants most likely to excite admiration, namely, the different forms of the corolla.

In selecting the form of the Corolla as the basis of his classification, Tournefort has, perhaps, contributed more to the progress of botany than any other *savant* of any age. The task of instruction was rendered a pleasure by thus taking, as a subject of scientific inquiry, the most attractive part of the plant. He soon made adepts of those who had hitherto only contemplated flowers as the source of an agreeable sensation.

Tournefort first established two grand divisions of the vegetable world, *Herbaceous Plants* and *Trees*. The flowers of herbaceous plants are furnished, or not, with a corolla; they are simple or compound; the corolla is *Monopetalous* or *Polypetalous;* it is regular or irregular. Such were some of the considerations on which Tournefort founded his classification of herbaceous vegetables.

As to trees, their flower is provided with a corolla, or it is not; that is to say, it is *Apetalous* or *Petalous*. The apetalous trees have the flowers disposed in catkins, or they have not; the petalous trees have the corolla regular or irregular.

Arranged and tabulated, according to the system of Tournefort, the vegetable world will stand as follows:—

FLOWER-BEARING TREES.

Apetalous	. . . . .		APETALOUS plants, properly so called.
			AMENTACEÆ.
Petalous.	Monopetalous	. . . . .	MONOPETALOUS.
	Polypetalous	regular . .	ROSACEÆ.
		irregular .	PAPILIONACEÆ.

Trees, then, form five classes.

In the class of *Apetalous* plants are ranged the Box-tree and the Pistachio; in the class of *Amentaceæ* are the Oak, the Walnut-tree, and the Willows.

The Lilies, the Elder, and the Catalpa of India belong to the *Monopetalous* division; the Apple, the Pear, and the Cherry to the *Rosaceæ*; the Acacia, the Laburnum, to the *Papilionaceæ*.

The herbaceous flowering plants without corolla are subdivided into three classes: (1) plants provided with stamens; (2) flowerless plants provided with seeds; (3) plants in which the flowers and fruits are not apparent. Wheat, Barley, and Rice belong to apetalous herbaceous plants, with stamens; the Ferns and Lichens to flowerless apetalous herbaceous plants, provided with fruits; and the Mosses and Mushrooms to apetalous herbaceous plants without flowers and having no apparent fruit.

Tournefort formed fourteen classes of flowering herbaceous plants provided with a corolla. The first twelve classes include the herbaceous plants with isolated and distinct flowers; the three others include the flowering herbs, which constitute the *compositeæ*, namely, the Floscular, or flowers with funnel-shaped petals; the semi-floscular and the radiating plants, such as the Sunflower and the Daisies.

The following is a tabular arrangement of simple-flowering herbaceous plants, according to the grouping of Tournefort:—

With Monopetalous corolla.	Regular	*Campaniform*	Campanula.
		Infundibuliform	Tobacco.
	Irregular	*Personate or masked*	Snap Dragon.
		Labiate	Salvia.
Polypetalous corolla.	Regular	*Cruciform*	Stock Gilliflower.
		Rosaceous	The Rose.
		Umbelliferous	Angelica.
		Caryophyllus	Pink.
		Liliaceous	Lily.
	Irregular	*Papilionaceous*	Pea.
		Anomalous.	Violet.

In addition, Tournefort has subdivided each class into sections, more or less considerable, based upon its composition, upon the consistence of its fruit, and upon some particular modifications of the form of the corolla.

Such is the first known system for the classification of plants. This scientific conception met with great favour among his contemporaries on account of its simplicity. Nevertheless, in its application this system presented many difficulties. The form of the corolla is not always so exactly appreciable that the class to which the plant belongs can be settled from that character alone. But the

gravest defect of the system is, that by it the vegetable world is divided into two classes, namely, Herbaceous Plants and Trees—a division which has no existence in nature. The division destroys the natural analogies, for the size of a plant has no bearing upon its organisation and structure. In conclusion, the continually increasing number of new species which were unknown in Tournefort's time, test, in the strongest manner, the defects of his system of distribution. The greater number of vegetable species discovered since Tournefort's time could not be placed in either of his classes. This defect soon became very apparent, and the system fell by degrees out of favour with botanists even among his own countrymen, with whom it had found most favour.

In England the study of plants had taken a more philosophical direction. About the middle of the seventeenth century the microscope was first applied to the study of the organs of plants, and the spiral vessel was detected by Henshaw, and shortly afterwards the cellular tissues were examined by Hooke. These discoveries were followed by the publication of two works on the Physiology of Plants by Malpighi and Grew. They examined the various forms of cellular tissues and intercellular passages in their minutest details, and with an exactness which causes their works still to be recognised as the groundwork of all physiological botany. The real nature of the sexual organs in plants was demonstrated by Grew; the important difference between seeds with one and those with two cotyledons was first pointed out by him. Clear and distinct ideas of the causes of vegetable phenomena were gradually developed, and a solid foundation laid on which the best theories of vegetation have been formed by subsequent botanists.

About the time when Tournefort was engaged in arranging his system of plants, and when Grew had completed his microscopical observations, John Ray appeared, driven from his collegiate employments at Oxford by differences of opinion with the ruling powers. He sought and found consolation in the study of natural history, to which he was naturally attached, and for which his natural powers of observation, capacious mind, and extensive learning, so highly qualified him. Profiting by the discoveries of Grew and other vegetable anatomists, in 1686 he published the first volume of his "Historia Plantarum," in which are embodied all the facts con-

nected with the structure and organs of plants, with an exposition of the philosophy of classification, the merits of which are better appreciated now than they were in his own days.

Ray was careful to guard his readers against the supposition that classification was other than a means of identification. He argued that there was no line of demarcation in nature between one group or order, or even genera, and another, or that any system could be perfect. "What, indeed, I said before, I now repeat and insist on," he says, "that a system is not to be expected from me, which shall be in every respect perfect and complete in all its parts; which shall so distribute plants into genera that every species shall be included, not one, hitherto anomalous and exceptional, being omitted; and which shall so mark out every genus by its peculiar indications and characteristics, that no species shall be found of uncertain family, so to speak, and referable to many genera. Nor by the very nature of things could this happen. For nature (as is sometimes said) makes no leaps, passing from one extreme to the other, but takes a middle course, between the highest and the lowest, producing a certain order of things of a neutral and ambiguous character, partaking of the qualities of the objects which most resemble them on either side, as if to connect them, leaving it sometimes doubtful to which of the two they belong. Besides, Nature objects to be coerced by the narrowness of any system; and as if to show that her liberty and independence is perfect, she is in the habit, in every part of creation, of producing singular and anomalous species, which form exceptions to the general rule."

While he thus enumerated the true principles of classification, Ray also laid the foundations of the inductive system, which has since distinguished the English school of Botany. He separated flowerless from flowering plants, and he divided them again into Monocotyledonous and Dicotyledonous plants.

Forty years after the publication of Tournefort's system, and while Ray was yet pursuing his philosophical investigations, the Linnæan system appeared. This new mode of distributing vegetable species was hailed with admiration. Its author, Charles von Linnæus, reigned supreme and without a rival till the end of the eighteenth century, and even in our days his partisans are neither

few nor powerless. In Germany, for instance, more than one Book of Character has for its foundation the system of Linnæus, and many school-gardens are arranged after his classification.

The system of Linnæus rests upon the consideration of the organs of fecundation—organs almost overlooked until then, but whose physiological functions have since been ably demonstrated. He introduced at the same time a salutary and much-wanted reform into botanical language and nomenclature, defining most rigorously the terms used to express the various modifications and characteristics of the organs, and reducing the name of each plant to two words, the first, *substantive*, designating the genera, the second, *adjective*, designating a species of the genera. Before Linnæus, in fact, it was necessary to follow the name of the genera through a whole phrase in order to characterise the species. As the number of species increased, the lengthened phrases were lost to view. It was like the confusion which would arise in society if, in place of using the family name and surname, we were to suppress the baptismal name, and substitute for it an enumeration of many qualities distinctive of the individual; as if, for example, in place of saying Pierre Durand or Louis Durand, we said Durand the great sportsman, or any other phraseology applicable to the qualities of the individual. The Linnæan or binary nomenclature, then, is one of the great titles to that glory which has been awarded to its immortal author. In the outline of the Linnæan system it has been found possible to describe all plants discovered since his time—an irrefragable proof of the great merits of this artificial classification of species.

At first Linnæus divided all known vegetables into two great groups: those in which the stamens and pistils are visible, which he called *Phanerogames;* and those in which these organs are hidden, which he called *Cryptogames.* These last form only a single class, namely, the twenty-fourth of his system.

Among the plants whose assemblage constituted the twenty-three classes, one portion have *hermaphrodite* flowers; the others are *unisexual.*

Plants with true sexual flowers have the male and female organs brought together on the same plant. They have a united habitation; they are *monaceous,* as the name of the class to which

the Oak, the Box-tree, Maize, and Castor Oil-plant belongs indicates. They are *monaceous*, and form the twenty-first of the Linnæan classes.

The male and female flowers are found upon two distinct individuals. There is a duality of habitation, as the name of the class

Fig 288.—Linnæus.

to which *Mercurialis*, the Date, and the Willow belong, indicates This is the class *Diæceæ*, and the twenty-second.

A class which is only a combination of the two preceding groups includes the plants which present upon one or many individuals male, female, and hermaphrodite flowers. This is the twenty third class, said to be *Polygamous*, on which we find ranged the Ash, the Pelitory, and the Nettle-tree.

Plants with hermaphrodite flowers have the stamens and the pistils borne the one upon the other, as in the *Orchidaceæ* and *Aristolochia;* they form the twentieth, or *Gynandrous* class. Sometimes the organs are non-adherent between them, in which case the stamens are free. Sometimes they are adherent. When they are free, they are either equal among themselves or unequal.

If the stamens are equal, their number determines the first twelve classes in the system. The twelfth and the thirteenth classes are founded upon the number of the stamens and their mode of insertion. The following are the classes:—

Linnæan Classification.

One Stamen in each flower	1st class.	Monandria (Hippuris, Cannæ).
Two Stamens	2nd class.	Diandria (Jasmin, Lilac).
Three Stamens.	3rd class.	Triandra (Wheat, Barley, Iris).
Four Stamens	4th class.	Tetrandria (Madder root, Joint Grass).
Five Stamens	5th class.	Pentandria (Borage, Hemlock).
Six Stamens	6th class.	Hexandria (Lily of the Valley, Lily).
Seven Stamens	7th class.	Heptandria (Horse Chesnut).
Eight Stamens	8th class.	Octandria (Heaths).
Nine Stamens	9th class.	Enneandria (Laurel).
Ten Stamens	10th class.	Decandria (Pink, Lychnis).
Eleven to Nineteen Stamens	11th class.	Dodecandria (Purple Willow).
Twenty Stamens or more, inserted upon the Calyx	12th class.	Icosandria (Myrtle, Rose).
Twenty Stamens or more, inserted upon the receptacle.	13th class.	Polyandria (Anemone, Poppy).

Linnæus founded two other classes upon the inequality of their free stamens, the *Didynamia* (fourteenth class), which comprises Thyme, Lavender, Foxglove, and Figwort, plants having four stamens, of which two are short and two long. The *Tetradynamia,* which comprises the Gilliflower, Cress, and Cabbage, have six stamens, of which four are larger than the others. When the stamens are adherent, the adhiscence has place either at their anthers or filaments. Plants which adhere to the anthers, such as the Corn-centaury, Dandelion, and Ox-eye, belong to the nineteenth class (*Syngenesia*). Those which unite to the filaments form three classes, the *Monadelphia* (sixteenth), in which all the filaments are united in one body, as in the Mallow; the *Diadelphia* (seventeenth), in which the filaments are united in two bodies, as in the Pea and the Bean; the *Polyadelphia* (eighteenth), in which the filaments are united in several bodies, as in the Orange.

The twenty-four classes being thus fixed, Linnæus, after some consideration, subdivided each of them—the thirteen first classes according to the number of their styles or distinct stigmata; the fourteenth (*Didynamia*) by the disposition of their seeds, sometimes bare (or at least what he considered as such), sometimes enclosed in a pericarp; the fifteenth (*Tetradynamia*) according to the form of the fruit; the sixteenth, seventeenth, eighteenth, and twentieth according to the absolute number of their stamens; the two following from the absolute number of their stamens, and from the manner of their adherence; the twenty-third class (*Polygamia*), from the distribution of the hermaphrodite and unisexual flowers upon the same plant, or upon two or three different. The nineteenth class (*Syngenesia*) is divided as follows:—

I. Flowers all fertile, hermaphroditic (*Polygamia equalis*), Goatsbeard, Lettuce, Thistle.

II. Hermaphrodital flowers, fruitful in the disks; female flowers, fruitful at the circumference (*Polygamia superflua*), Tansy, Wormwood, Groundsel.

III. Hermaphrodital flowers, fruitful in the disk; neutral flowers, sterile at the circumference (*Polygamia frustranea*), Centaury, Sunflower.

IV. Hermaphrodital flowers, sterile in their disks; female flowers, fertile at the circumference (*Polygamia necessarea*), Marigold.

V. Flowers provided with a proper and clustered calyx, under a common calyx (*Polygamia segregata*); separated flowers (*Monogamia*), Lobelia, Violet.

This classification of plants has received the name of the artificial system, because it groups the species according to a small number, and not from the whole of their characteristics; in short, it rather permits one species to be distinguished from another, than makes each known in an intimate manner. It insists much upon their differences, little upon their resemblances. Between species thus compared, only one essential analogy may exist. The Rush takes place beside the Barberry, because each of these plants have six stamens and only one style. The Vine is ranged beside the Periwinkle, because they each have five stamens and one style. The Carrot is allied to the Gooseberry, &c. There may not be between the plants thus compared any natural bond, any essential characteristic,

but only some trace of resemblance in the organisation, which may be found also in a number of very different plants.

Linnæus was endowed with too sound a judgment, with a tact too exquisite, not to feel the defects of this artificial mode of classification. He detected by the force of his genius the existence of vegetable groups superior to genera, and connected them by a large number of characteristics. He called this group a *natural order*, and it has since his time been called the "natural family." He also tried to distribute plants after a natural classification—that is to say, into families. After the death, and during the life, of Linnæus, botanists endeavoured to discover upon what principle he had founded his *natural orders*—that is to say, they sought to find the key to the hidden principle of his orders; but no one has succeeded. Linnæus himself does not appear to have had very fixed views on the subject. He created his orders by a sort of instinct which belongs only to the man of genius; by that kind of semi-divination which the man of learning acquires who possesses vast and profound knowledge of the objects which he passes his life in observing.

Linnæus created his natural orders, then, without any well-premeditated plan, and without having compared any well-defined assemblage of organs; this is sufficiently proved by the following conversation with one of his pupils named Giseke, which has been preserved, and which we consider sufficiently interesting to repeat here, leaving the interlocutors to speak each for himself:—

LINNÆUS. Do you think, my dear Giseke, you are able to give the characters of any one of my orders?

GISEKE. Yes, without doubt; for example, that of the umbellifera.

LINNÆUS. Well, what of it?

GISEKE. Just this, to be umbelliferous it must bear flowers disposed in an umbelle.

LINNÆUS. Very good; but you will readily recollect some plants whose flowers form an umbelle which nevertheless do not belong to the order?

GISEKE. That is true, I recollect some. I will add the two naked seeds.

LINNÆUS. Then, the *Echinophora* will not be of the order, for it has only one seed in the centre of the peduncle. Nevertheless it is an umbelliferous plant. And where do you place the *Eryngium?*

GISEKE. Among the *Agregata.*

LINNÆUS. Not at all; it is most certainly an umbellifera, for it has an involucre, five stamens, two pistils. What then shall be its character?

GISEKE. Such plants ought to be placed at the end of an order where they may bridge over the passage from one to another. The *Eryngium* would thus connect the *Umbellifera* with the *Aggregata.*

LINNÆUS. Oh, no, that is quite another thing; it is one thing to know the

passages between, and another to describe the characters of two groups. I know them very well, and how the one ought to be joined to the other. One of our former pupils, named Fagraux, who is now at St. Petersburg, a most industrious young man, was quite wild upon the project of discovering the key to my orders. He laboured nearly three years, and sent me his ravings. I could only laugh. In short, I can tell you one thing,—if I publish a second edition of my book, I shall give a second arrangement of my orders.

In a letter to the same botanist, we find the following passage: "You ask me for the characters of my orders. My dear Giseke, I assure you that I know not how to give them."

Fig 289.—Magnol.

M. Magnol, Professor of Botany to the School of Medicine, in his work entitled "Prodromus Historiæ Generalis Plantarum,"

is the first author who uses the happy term "family" to designate natural groups of vegetable genera. M. Florens speaks of the preface to this little book of a hundred pages as calculated to immortalise the author, as in it was first solved a very difficult problem. The following lines are taken from this much admired preface: "Having examined the methods most in use," says Magnol, "and found that of Morison insufficient and very defective, and that of Ray much too difficult, I think I can perceive in plants a certain affinity between them, so that they might be ranged in divers *families*, as we class animals. This apparent analogy between animals and plants has induced me to arrange them in certain families, and, as it appeared to me impossible to draw the characters of these families from the single organ of fructification, I have selected principally the most noted characteristics I have met with, such as the root, the stem, the flower, the seeds. There is also found among plants *a certain similitude*, a certain affinity, as it were, which does not exist in any of the parts considered separately, but only as a whole. I have no doubt, for instance, but that the characters of families might be taken from the first leaf of the germ as it issued from the seed. I have followed the order that protects the parts of plants in which are found the principal and distinctive family marks, but without limiting myself to any one single part; for I have often considered many of them together."

Magnol established seventy-six families, but without giving their characters. His principles of classification are vague and uncertain; they only serve to announce the dawn of a new day which was soon to rise on the science. The few lines which we have quoted from the preface of the "Prodromus" reveals, as through a fog, the mere idea of a natural system. It is Bernard de Jussieu, Demonstrator of Botany in the Jardin des Plantes at Paris, to whom belongs the glory of working out the true natural system which was first established in principle by Ray, although it does not appear that Jussieu was acquainted with the works of the English philosopher.

Bernard de Jussieu, as his nephew Laurent de Jussieu tells us, regarded botany, not as a science of memory or nomenclature, but as a science of combination, founded on a profound knowledge of

the characteristics of each plant. He would every day get together the materials out of which he had to form his natural orders, which he regarded as the "philosopher's stone" of botanists. He deferred the publication of his first Essay in his zeal and desire to perfect his work. He wrote little, but observed much, and the

Fig. 290.—Bernard de Jussieu.

fruits of his labour would perhaps have been lost to science but for a favourable circumstance which obliged him to give his method of arrangement of plants to the world. Louis XIV. having seen the gardens of Saint Germains, in which the

Marshal Duke de Noailles cultivated exotic trees and shrubs, formed the design of creating a School of Botany at Trianon. By the advice of Lemonnier, chief physician to the Child of France, afterwards King, he selected Bernard de Jussieu to arrange the gardens. Thus forced to adopt some mode of classification, he thought it his duty to substitute his new method. This method consisted in having a *tableau raisonné* on which the plants were arranged in a convenient order for studying them. Science confined to such narrow limits is, however, very fictitious, and remote from a natural system, which consists in the knowledge of the true connection of plants and their organisation. "When a man has so combined the characteristics of plants," says Laurent de Jussieu, "that he can in one species unknown determine the existence of many by the presence of a single character; when he can at once point to the order to which it belongs; when he has succeeded in destroying the prejudice so withering to Botany, that it is only a science of memory and nomenclature; when he has, in short, founded a science of combinations which furnish food to the mind and to the imagination, that man may surely be called the creator, or at least the restorer, of science."

"Others may perhaps have extended the limits, but he was the first to show the way, to trace the method, establish the principles. Jussieu consigned his discoveries to no book, but in the Gardens of Trianon the mind of the author is recognised. In examining the characters, he remarked that some were more general than others, and these furnished the first division. Having appreciated and appropriated these, he next recognised that the germination of the seed and the respective disposition of the sexual organs were the two principal and most persistent characteristics. He adopted them, and made them the basis of the arrangement which he established at Trianon in 1759."

Four years later, another French botanist, Michel Adanson, a naturalist, remarkable for the originality of his views and the extent of his conceptions, published quite a book upon the families of plants. He proposed a particular course for arriving at the true natural method. But what was that course? He proposed classing all the plants known according to a great number of artificial systems, and after considering them from all possible

points of view; he proposed to arrange in the same group those

In this manner Adanson created sixty-five artificial systems, and by their comparison, he formed them into fifty-eight families. He was the first to trace the precise characters and details of all these families; his work in this respect is far superior to those

Fig. 291.—Adanson.

of his predecessors. Nevertheless if Michel Adanson was right in employing all their characteristics in classifying these plants, he was wrong, on the other hand, in giving the same importance to all. He reckoned up the characters without considering that

they were not all of equal value. The results of his calculations were frequently found to be false, as would inevitably happen with any sum where no regard was paid to the quality of the metal, but only to the shape and volume of the coin.

The year 1789 was the date of the true creation of natural families among vegetables. It was about this time that Laurent de Jussieu published his celebrated "Genera Plantarum," which raised the science of botany, and marked a new era, not only in vegetable science, but in the classification of animals.

The catalogues of the Gardens of the Trianon, prepared by Bernard de Jussieu, and the conversations of the latter with his nephew, were the primitive spark whence the latter drew his inspiration. We shall, however, leave his grandson, Adrien de Jussieu, to state the true basis of the Natural System, and the considerations which guided his relation. "Like Adanson," says Adrien, "Antoine-Laurent de Jussieu admits that the examination of all parts of a plant is necessary in order to its classification; but in pursuing this examination it is not sought to deduce theoretically the combination of the genera; thus in grouping them into families, he imitated the proceedings followed in the formation of the genera themselves. The botanist, struck by the complete and constant resemblance of certain individual plants, formed them into species; then, observing a resemblance equally constant, but much less perfect, he formed them into genera. The characters, which might vary even in the same species, ought to depend on causes exterior to the plant, and not on the plant itself: for example, its size, consistence, certain modifications of form and colour, which we see change with the sun, the climate, and under other influences purely circumstantial. The specific characters, on the contrary, those especially which every individual should possess, as belonging to certain species, whatever be the circumstances in which they are found, ought to hold to the nature of the plant. Among these characters some are more important than others, and less subject to variation. Finding these characters in a certain number of species marks what constitutes a genus. These would, from their general nature, have more value than the specific, as the specific is of more value than the individual characteristics.

"But how are we to discover and estimate these different values?

Nature herself indicates to the observer the species and many of the genera, by the features of resemblance with which she marks certain vegetables. All botanists are nearly agreed up to this point; although they separate further on to follow each a different road. Nevertheless, there are many great groups of vegetables connected together by features so strong in their resemblance that it could scarcely escape observation; it requires no botanist to recognise them. Besides these features common to all the species constituting one of these groups, there are others which are only common to a certain number of them, so that it may be subdivided again by a great number of secondary groups. These had been recognised as genera by botanists. We had already, then, some collections of genera evidently possessing more resemblance to each other than they had to any other group; in other words, there were some families incontestably natural. Jussieu thought that the key to the natural method was there; since, in comparing the character of one of those families with the genera composing it, he would obtain a knowledge of the relation of one to the other; and in comparing many among them, he would see how the characters common to all plants of the same family varied one from the other; he would thus arrive at a true appreciation of the value of each character, and this value, once determined by means of groups so clearly designed by nature, could be applied in its turn to the determination of others which were not so strongly impressed with the family seal; others which were the unknown in the great problem. He selected for this purpose seven families already universally recognised; those, namely, known as the Graminaceæ, the Liliaceæ, the Labiatæ, the Compositæ, the Umbelliferæ, the Cruciferæ, and the Leguminosæ.

"It is recognised that the embryo is identical in all plants of any of these families; it is monocotyledonous in the Graminaceæ and Liliaceæ, and dicotyledonous in the other five. The structure of the seed is also identical, the monocotyledonous embryo being placed in the axis of a fleshy albumen in the Liliaceæ, and upon the side of a farinaceous perisperm in the Graminaceæ, while the dicotyledonous embryo is placed at the summit of a hard and horny albumen in the Umbelliferæ, and is destitute of albumen in the three others. That the stamens which vary in their number in the same family, the Graminaceæ, for example, do not

vary in general in their mode of insertion, being hypogynous in the Graminaceæ and Cruciferæ, upon the corolla in the Labiatæ and Compositæ, and upon an epigynous disk in the Umbelliferæ. He obtained thus the true value of certain characters which ought never to vary in the same family; but along with these he found

Fig. 292.—Laurent de Jussieu.

others more variable, which he sought to appreciate also, either to assist him in the study of other families analogous to them, or in explaining those which he had formed, by applying his first rules along with many others founded on observation. We cannot, however, follow him here into these details, which resulted,

after immense labour, in the establishment of a hundred families, comprehending all the vegetables then known.

"We see in these remarks a principle employed which had altogether escaped the notice of Adanson—namely, that subordination of character which in the method of Jussieu is, to use his own expression, 'weighed but not counted.'"

When the families were constituted, Laurent de Jussieu grouped them into fifteen classes, as in the following table:—

Acotyledonous			Class I.	1. Fungi. 2. Lichens.. 3. Ferns. 2. Algæ. 3. Hypaticæ. 4. Musci, or Mosses. 5. Feliceæ, or Ferns. 6. Naiades, or Water-plants.	Comprising Mushrooms, Algæ, Hepaticas, Mosses, Ferns, and corresponding with the Cryptomamia of Linnæus.
Monocotyledonous.		Stamens Hypogynous.	Class II.	7. Aroideæ, Arums, &c. 8. Typhæ, or Reeds. 9. Cyperoideæ, or Sedges. 10. Gramineæ, or Grasses.	Comprising the Arums, Mace, Gallengales, Grasses, Sugar Cane, &c.
		Stamens Perigynous.	Class III.	11. Palmæ, Palms. 12. Asparagi. 13. Junci, Rushes. 14. Liliæ. 15. Bromeliæ. 16. Asphodeli. 17. Narcissi. 18. Irides.	Comprising the Palms, Asparagas, Rushes, Asphodels, Narcissus, Iris.
		Stamens Epigynous.	Class IV.	19. Musæ, Anani. 20. Cannæ, Indian Shots. 21. Orchideæ. 22. Hydrocharides, Water-plants.	Comprising the Bananas, Indian Shot, Orchids.
Dicotyledonous.	Apetalous.	Stamens Epigynous. Stamens Aerigynous. Stamens Hypogynous.	Class V. Class VI. Class VII.	23. Aristolocheæ. 24. Elæagni. 25. Thymelæ. 26. Protaceæ. 27. Lauri, Laurels. 28. Polygonæ. 29. Atriplerieæ. 30. Amaranthe. 31. Plantagines. 32. Nyctigines. 33. Plumbagynes.	Among the Apetalous plants are ranged the Aristolochea with their horn-like flowers, from the fifth class. The Elæagni, or chaste tree, a desert bearing tree of Persia, the refreshing Thymus, the Laurels, and many jointed Polygons, to the sixth class. And the Amaranths, Plantains, and Nyctagons, in the seventh class.
	Monopetalous	Corolla Hypogynous. Corolla Perigynous Epigynous. Anthers Attached. Epigynous. Anthers, Free.	Class VIII. Class IX. Class X. Class XI.	34. Lysimachiæ. 35. Pedunclaris. 36. Acanthi. 37. Jasminæ. 38. Vitices. 39. Serbiatæ. 40. Scrophulariæ. 41. Solanæ. 42. Boragineæ. 43. Convolvuli. 44. Polernomea. 45. Bignonæ. 46. Gentianæ. 47. Apocinæ. 48. Sapatæ. 49. Guaiacannæ. 50. Rhododendræ. 51. Criceæ. 52. Campanulaceæ. 53. Chicoraceæ. 54. Cinarocephalæ. 55. Cerymbiferæ. 56. Depsaceæ. 57. Rubiaceæ. 58. Caprifolia.	Among Monapetalous plants are the Loose Strife, Acanthus, Jasmines, the lipped or Labiate plants, the Figworts or Scrophulariæ, the Solanæ, which yields us the potato; and many other useful as well as dangerous products belong to the eighth class, with The Bindweeds, Trumpet flowers, and Gentians. The Ebony tree, beautiful Oleander, Heaths, and Campanulas belong to the ninth class. The Chicoraceous and corymb-bearing plants belong to the tenth class. The Honeysuckle and Madderworts to the eleventh class.

Dicotyledonous.	Polypetalous.	Stamens Epigynous.	Class XII.	59. Araliæ. 60. Umbelliferæ. 61. Ranunculaceæ. 62. Papaveraceæ. 63. Cruciferæ. 64. Capparides. 65. Sapindi. 66. Acera. 67. Malpighiæ. 68. Hyperica. 69. Guttiferæ. 70. Aurantia. 71. Miliæ. 72. Vites. 73. Geraniæ. 74. Malvaceæ. 75. Magnoliæ. 76. Anonæ. [illegible] Menisperma. [illegible] Berberides. 79. Tiliaceæ. 80. Cisti. 81. Rutaceæ. 82. Caryophyllæ. 83. Sempervivæ. 84. Saxifragæ. 85. Cacti. 86. Portulaceæ. 87. Ficoidæ. 88. Onagræ 89. Myrti. 90. Melastomæ. 91. Silicariæ. 92. Rosaceæ. 93. Leguminosæ. 94. Terebintaceæ. 95. Rhamni,	Among Polypetalous Dicotyledons are classed the Azaleas, and Umbelliferæ belonged to the twelfth class. The numerous families of thirteenth class included many of our favourite flowering plants and fruits, as the Ranunculus, the Cruciferæ, Maples, St. John's Wort, Oranges, Geraniums, Vines, Magnolias. The fourteenth contained the Saxifrages, Marigolds, and Myrtles, the Houseleeks and Roses.
		Stamens Hypogynous.	Class XIII.		
		Stamens Perigynous.	Class XIV.		
Diclinis Irregular . . .			Class XV.	96. Euphorbiæ. 97. Cucurbitaceæ. 98. Urticæ. 99. Amentaceæ. 100. Coniferæ.	The fifteenth class includes the Eupherbiæ, Cucumbers, the Nettle plants, the catkin-bearing Amentaceæ, and the cone bearers.

Such, then, was the arrangement into which Antoine-Laurent de Jussieu distributed the twenty thousand plants known to botanists in 1789. The hundred orders or families he further subdivided into 1,754 genera. That the French botanist had acquainted himself with the principles of Ray's classification is unquestionable; in fact, Jussieu possessed the happy art of adapting the labours of others to perfecting his own conceptions. He made use of the simple language and accurate descriptions of Linnæus, divested of his pedantry. Ray had demonstrated that rigorous definitions in natural history are impossible, and, accepting the decision, Jussieu does not attempt to found his family orders or genera on any single character belonging to objects so various in their habits and organisation as plants.

During the last forty or fifty years other botanists have attempted various systems of classification, but none so successfully as the late Dr. Lindley, whose works are distinguished beyond all

others for careful research, directed by a vast and comprehensive grasp of his subject. In the classifications of De Candolle, Endlicher, and of M. Brongniart, the distribution of plants into families is founded, like that of Ray and Jussieu, on the consideration of the cotyledons; of the petalous, monopetalous, and apetalous corolla; finally, upon the mode of insertion of the stamens. Names have changed; things remain the same; and if in their details the series of families present certain differences, it only arises from the fact that a linear series is incompatible with the natural system, and that the connection of the intermediate groups may be expressed in various ways without affecting the general principles of the system. "The formation of natural orders by De Jussieu," says Ad. Brongniart, "is even now a model which directs botanists in their studies to the affinity which connects the various forms of vegetation. Many of these orders have doubtless been subjected to important modifications, both as extending and limiting them; the numbers have been more than doubled; but the number of species now known is increased more than sixfold. Since the publication of the 'Genera Plantarum,' many points in the organisation of plants which were either scarcely touched upon or were altogether unsuspected, have now been considered, and it is found that they do not destroy, but confirm and perfect the work of Jussieu. One is even astonished to find that the numerous discoveries in the anatomy and organigraphy of plants since the beginning of the century have not introduced greater modifications into the constitution of the natural groups admitted by the author of the 'Genera Plantarum.' It is here that we recognise the sagacity of the savant who established them, and the soundness of the principle which guided him."

The natural classification of plants, their distribution into families, well defined, and founded upon affinities, have been perfected and placed upon a basis more and more certain in our own days. Botanists have set themselves the task of unravelling and establishing the characters which dominate, and those which are subordinate, in each family; great numbers have spread themselves over the globe, exploring the most distant regions, interrogating the solitudes of forests and plains, which no European had hitherto visited, and have studied in their native wilds many exotic

plants, comparing them with European species, thus giving us a means of pointing out more precisely the genera, tribes, and species of each natural family. Monographs of a great number of such families have thus been traced with profound patience. The study of the formation and evolution of organs; the discovery of the

F.g 293.—De Candolle.

true mode of reproduction in cryptogams, still unknown in D Jussieu's time; that of inflorescence, of the ovules, of the embryo of the fruits, have furnished elements for perfecting the limits families and advancing natural classification.

Auguste Pyramus de Candolle is one of the botanists of th

century who has most contributed to the general adoption of natural families. His "Essai sur les Properties des Plantes" is celebrated for the knowledge which it displays of the comparative physiological and physical action of vegetables, and the physical organisation which naturally connects certain plants as a group. His "Prodromus Systamatis Naturalis regni Vegetabiles," especially the latest edition by his pupils and his son, is also a wonderful work for the extent and precision of its details.

In our own country, from the days of Ray, we have always had zealous followers of the science of botany, more especially in the class which may be called field botanists. Withering, Sir Edward Smith, and hundreds of followers more or less eminent, employed their leisure in the fascinating and healthy pursuit of species, and perhaps the most valuable contributions to science are the detailed descriptions of species, with their habits and habitats, which have enriched our botanical literature. Nor was the study of the physiology of plants—a science which may be said to owe its existence to the researches of Grew and Malpeghi — neglected. To the former belongs the merit of having pointed out the difference between seeds with one and seeds with two cotyledons, on which Ray founded his system of classification.

The German botanists have always been distinguished for their patient and laborious investigations, and it was reserved for the first of Germans, the poet Goethe, to effect the last great revolution that the ideas of botanists have undergone. In 1790, shortly after the appearance of De Jussieu's "Genera," he published a pamphlet on the "Metamorphosis of Plants." At this time the functions of the organs of plants were supposed to be pretty well understood. Goethe had probably in the course of his reading stumbled upon the notion which has existed from the times of Theophrastus, that certain forms of leaves were mere modifications of others whose appearance was very different; a doctrine which Linnæus seems to have entertained at one time, as he speaks in his "Prolepsis Plantarum" of the parts of a flower being mere modifications of leaves whose period of development was anticipated. Goethe takes up this theory, and demonstrates that the organs to which so many different names are applied, namely, the bracts, calyx, corolla, stamens, and pistil, are all modifications of the leaf; the

bract being a contracted leaf, the calyx and corolla a combination of several, the stamens, contracted and coloured leaves in a state of disintegration, and the pistil, leaves rolled up according to certain laws.

These views of the poet met at first with little attention from

Fig. 294 —Robert Brown.

botanists, and we are chiefly indebted to Robert Brown for the elucidation of Goethe's theory. In his "Prodromus of the Plants of New Holland," and in many papers in the Philosophical and Linnæan Transactions, he demonstrates its truth as well as its

practical value; showing, by the use of the microscope, that the law was applicable not only to the external parts of plants, but to the development of their tissues also. Besides the debt which science owes to Robert Brown, he contributed largely to perfecting the natural method of classification. His great work upon the *Flora* of Australia has greatly extended the circle for that comparison of characters which is the basis of botanical genera and tribes.

The number of families admitted in the present day as the result of the investigations of the eminent men whose names have been mentioned, and many others which could not be quoted here without swelling our pages to undue proportions, number THREE HUNDRED AND THREE; and many of these are again subdivided by botanists who have made certain families their special study.

We have had a tabular view of the vegetable world as arranged by Adrien de Jussieu. According to the modifications introduced by De Candolle, plants are divided into two great classes, *Cryptogames* and *Phanerogames*.

The CRYPTOGAMIA, from γάμος, nuptials, and χρυπτός, hidden, are destitute of pistils and stamens: they are reproduced by means of divers organs which seem to have no other analogy, except by their functions, with the reproductive organs in other plants. They present no cotyledon, and yet they cannot be classed among acotyledonous plants.

The PHANEROGAMES, from γάμος and φανερός, visible, have perceptible reproductive organs formed of stamens and ovules, naked or enclosed in a kind of pistil.

According, then, as Phanerogames have an embryo furnished with one or two cotyledons, they are divided into two great natural groups, the Monocotyledons or Dicotyledons.

Adrien de Jussieu divided the Cryptogames, as we have seen, into two classes: *Cellular Cryptogamia*, including those composed of a vegetable tissue only, not traversed by *vessels*; and *Vascular Cryptogamia*, those provided with vessels. As regards *Phanerogamia*, he arranged them in one great division, calling them *Monocotyledonous Phanerogames;* distributing them, however, into two classes—(1) *Gymnospermes*, or *naked-seeded*, from γυμνός, naked, and σπέρμα, seed; and (2) *Angiospermes* (*plants with seeds*

enclosed in the fruit), from αγγεῖον, capsuled, and σπέρμα, seed. The dicotyledonous gymnospermes of De Jussieu formed only five families, and comprehended what we call Evergreens; the dicotyledonous angiospermes were divided into many secondary groups, whose distinctive characters were drawn from peculiarities of the reproductive organs.

Whilst the labours of the eminent men we have named were laying the foundations of the science, assisted by others only a degree lower, both in France and Germany, English botany was laying its own foundations. Robert Brown was no systematist. He was much struck with Goethe's ideas of the morphology of plants. Working with the microscope, he applied the theory to the development of the tissues of plants; and every new fact served to confirm him in the belief that the principle was universal. But the man of all others to whom modern science is most indebted for perfecting the botanical arrangement of plants, is the late Dr. Lindley. His knowledge of vegetable structure was extensive and profound. His indefatigable industry and unequalled powers of generalisation enabled him to grapple with and bring to perfection the vast scheme of re-arranging on physiological principles, after careful structural examination, the whole vegetable world. His "Vegetable Kingdom" remains a monument of immense learning, technical knowledge, and vast industry. The modern school of botanists may be said, one and all, to have been his pupils, and the system he has framed is probably the nearest to perfection which the world has yet seen; and M. Figuier must excuse the editor of the English translation when he adopts a system which has superseded all others in the British schools.

The basis of this system is a close examination of the minuter parts of plants, particularly the seeds; since, of all parts of plants, that is the one which displays the greatest constancy. The difficulties in comprehending it lie at the threshold; and in overcoming them the student has the gratification of gaining a vast amount of interesting information. The following is a brief condensation of Professor Lindley's scheme from the "Vegetable Kingdom," (p. lv. *et seq.*), whose parting advice to his readers is, to bear in mind that under the natural system the stamens and pistils play a subordinate part, and are only accounted as a portion of the whole

plant; but very minute and constant attention should be directed to the ovule and the seed, so that a pocket magnifier of moderate power is absolutely necessary in examining plants on this system." We can only give an outline of this great scheme, following it up with a short notice of the orders, and filling up the sketch with a few details of the species most interesting to man. The object of a systematic arrangement of plants being to bring together groups according to their apparent relationship to each other, that adopted by Dr. Lindley classes them as—(1) *Thallogens*, from θάλαμος, the bridal chamber; (2) *Acrogens*, from ἄκρος, topmost, and γενάω, to produce; (3) *Rhizogens*, from ρίζωμα, a root; (4) *Endogens*, from ενδον and γενναω, produced within; (5) *Dictyogens*, netted, from δικτυς, a net, and γενεσθαι, to be; (6) *Gymnogens*, from γυμνος, naked; (7) *Exogens*, from εξ and γενεσθαι, to grow by external additions.

The Acrogens are here identical in their limits with the *Acotyledons* of De Jussieu, the *Exembryonatæ* of Richard, the *Celullares* of De Candolle, the *Agamæ* of various authors, and the *Cryptogamia* of Linnæus. The term itself is, however, only applicable literally to flowerless plants, which possess a stem growing like the Exogens, so that the stemless plants are classed as *Thallogens*. This is, however, but an artificial character; and some recent botanists regard Thallogens as a section of Acrogens.

Asexual or Flowerless Plants.

I. Thallogens .	Stems and leaves imperceptible.	A Thallus is a fusion of root, stem, and leaves into one general mass, and Thallogens are also destitute of flowers, without breathing pores, and they multiply by the formation of spheroids, called spores, in their interior or upon their surface.
II. Acrogens . .	Stems and leaves quite perceptible.	Beyond Thallogens are multitudes of species, flowerless like them, but approximating to more complex structures, sometimes acquiring *the stature of lofty trees* with breathing pores; their leaves and stems distinctly separated; some of them having the spiral filament which is supposed to belong to a higher structural development; finally they multiply by reproductive spores like the Thallogens Their stem, however, does not increase in diameter, but at their summit, as the name of the class indicates.

Sexual or Flowering Plants.

III. Rhizogens . .	Fructification springing from a Thallus.	The Rhizogens are a collection of anomalous plants, mostly leafless and parasitical, having the loose cellular organisation of Fungi, although traces of a spiral structure are usually found among their tissues. Some of them spring directly from the shapeless cellular mass which serves at once for stem and root, and seems to be analogous to the Thallus of the Fungi. Their flowers resemble those of more perfect plants; their sexual organs are complete, but their embryo, which is without any visible radicle or cotyledon, simply appears to be a spherical or oblong homogeneous mass.
IV. Endogens . .	Fructification sprung from a Stem. Wood of stem youngest at the centre; cotyledon single. Leaves parallel veined; permanent woody stem confused.	In Endogens the germination is endorhizal, whose embryo has but one cotyledon, whose leaves have parallel veins, and whose trunk is formed of bundles of spiral and dotted vessels, guarded by wooded tubes arranged in a confused manner, and are reproduced in the centre of the trunk.
V. Dictyogens .	Deciduous; leaves net-veined; wood of the stem, when perennial, arranged in a circle with the central pith.	Dictyogens are distinguished from Endogens by the roots, which have no concentric circles, and the leaves fall off the stem by a clean fracture, as in that class.
VI. Gymnogens .	Wood of the stem almost concentric, and youngest at the circumference between the wood and the bark. Cotyledons, two or more. Seeds quite naked.	Gymnogens are Exogens, which have no style or stigma, the reproductive organs being so constructed that the pollen falls immediately upon the ovules, a peculiarity analogous to what occurs among reptiles in the animal creation.
VII. Exogens . .	Seeds enclosed in seed vessels.	Exogens consist of innumerable cases having exorhizal germination; an embryo with two or more cotyledons; leaves with a net-work of veins; trunk consisting of woody bundles, composed of dotted and woody tubes or woody tubes alone, arranged round a central pith, either in concentric rings or in a homogeneous mass, but always having medullary plates forming rays from the centre to the circumference, and reproduced on the circumference of the trunk; whence their name.

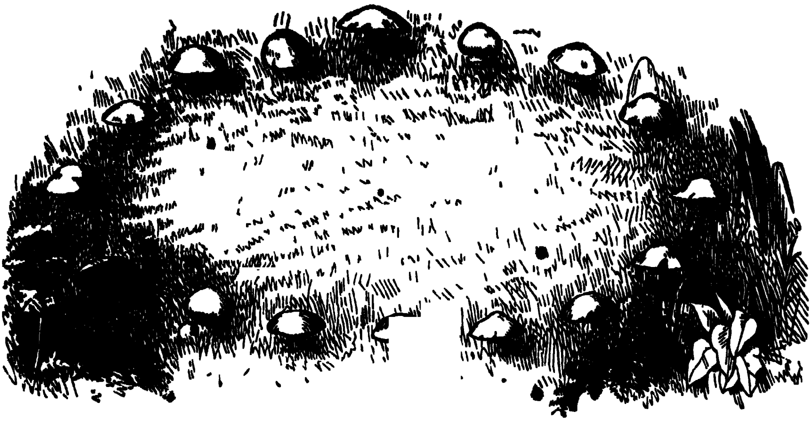


Fig. 295.

Thallogens.

The Thallogens of recent botanists correspond in all respects with the Cryptogamia of older botanists, a name given to this division of the vegetable world, not from their reproductive organs being invisible, as has long been admitted, but from their being inconspicuous, and requiring close observation, and some exact knowledge of their organisation, in order to discern them. If we enter on a somewhat minute investigation of this important group, we are led to do so by the consideration that their organisation, structure, and development is not usually attempted in elementary botanical works; and we feel assured that the interest and novelty of the observations we shall have to offer will be our apology for the relative extent of our descriptions.

The division includes vegetables destitute of stamens and of pistils, whose embryo is simple, homogeneous, and without distinct organs. A great number of them are of minute microscopic dimensions; their reproductive organs can only be distinguished by the help of a lens or a microscope. Nevertheless, these being so small, so humble, and to all appearance all but forgotten in more important creations, fulfil an important part in the economy of nature. They constituted the first origin, and were even the source of all vegetation. Disaggregating rocks, they produced the vegetable earth which became the means of their own destruction. The enriched soil nourished plants of more complex organisation,

and these inferior beings were replaced by degrees by vegetable species of more perfect structure. All soil primitively sterile, all land recently emerged from the bosom of the waters, served first as the asylum of crustaceous and foliaceous Lichens; at a later period Mosses and Ferns made their appearance there; finally, a superior vegetation—namely, the Phanerogames, or Cotyledons—present themselves. Everything leads us to conclude that such has been the successive series of creations upon our globe, when it was sufficiently cooled on the surface to admit of organic life, and when the islands and continents were sufficiently elevated above the universal ocean of the ancient world to permit them to live.

Thus the higher orders of vegetables have only appeared, and will only continue to make their appearance, upon the *débris* of vegetation of a lower order.

But, on the other hand, by one of those striking contrasts of which Nature offers more than one example, vegetables of a superior order, when they are struck by death—sometimes even during their existence—are often the prey of humbler Thallogens, which attach themselves as parasites to these princes of the vegetable world, and devour them in the end; their destructive action is all-powerful and everywhere; it respects the works of man no more than the works of nature.

To produce and to destroy life is, then, the double and providential mission which devolves on the Thallogens. Nevertheless this multiplied work of creation and death is only bestowed on them on two conditions: the first is an evanescent and short existence, the second is to multiply themselves to infinity and with prodigious rapidity. There are some mushrooms which produce sixty thousand tetricales or cells per minute! The capsules of certain mosses enclose seeds of which it would require many thousands to make a pin's head in size. These seeds float free and invisible in the air, which is in a sense saturated with them.

In the Cryptogama the reproductive organs in a fundamental manner form the phanerogames. Here, without pistil or stamens, no ovary, no flower, in the ordinary sense of the word, the reproductive organs which are designated spores are disseminated in a most varied manner, sometimes in its whole extent, sometimes in certain parts of the vegetable. These spores are sometimes

enclosed in special receptacles named sporanges, in other cases they are quite destitute of any envelope. In short, the reproduction of thallogens is often the result of organic dispositions, quite special, which admit of no general description, and which can only be made intelligible by describing each individual case.

To examine all the families which constitute the class would be an immense undertaking. We shall confine ourselves to examine attentively certain types of the five families by Algæ, Fungales, Lichens, Mosses, and Ferns :—

SUB-CLASS.	CLASS I.—THALLOGENS.	NATURAL ORDERS.
1. ALGALES.	Cellular flowerless plants, nourished by the medium on which they vegetate; propagated by zoospores, spores, or tetraspores.	I. Diatomaceæ, or bush nuts. II. Conifeiæ III. Fucaceæ, or sea-weed. IV. Ceramiaceæ. V. Characeæ.
2. FUNGALES.	Cellular flowerless plants, nourished through their thallus, living on air, propagated by spores, sometimes enclosed in asci, destitute of green gonoids.	VI. Agaricaceæ, toad-stools. VII. Gasteromycetas,or puff-balls. VIII. Goniomycetes, or blights. IX. Botrytaceæ, or mildews. X. Ascomycetes, or morels. XI. Physymycetes, or moulds.
3. LICHENALES.	Cellular flowerless plants, nourished through their whole surface by the medium on which they vegetate, living on the air propagated by spores enclosed generally in asci, with green gonoidea in their thallus.	XII. Graphidaceæ, cell-lichens. XIII. Collemaceæ, or jelly-lichens. XIV. Parmelliaceæ,or leaf-lichens.

I. DIATOMACEÆ.

Crystalline fragmentary bodies, which attach themselves to stones constantly under water, and so obscure in their organisation that it still remains a grave question whether they belong more to the animal or vegetable creation. Ehrenberg inclines decidedly to the former opinion, assigning as reasons that they exhibit a peculiar spontaneous movement, produced by locomotive organs; that many of them have a lateral opening, round which are corpuscles, which become blue when placed in water coloured with indigo, like many *Infusoria;* their shells, or shield, are in structure similar to the *Molusca.* Schleiden considers that such an artificial and complex structure as exists in the *Diatomacea* is without explanation; of great significance, and without "analogy in the vegetable world."

On the other hand, the discovery of Mr. Thwaites discloses operations strictly in accordance with what occurs in the animal kingdom. In *Fragilaria pectinalis,* two individuals closely approximated *dehisce* in the middle of their long diameter; four pro-

tuberances now rise, which meet four similar ones in the opposite frustule, indicating the future channels by which the two frustules become united, as well as the spot where the double sporangium is afterwards developed.

II. Confervaceæ.

Towards the close of the year, in autumn, on moist, humid days, or after a heavy fall of rain, we frequently meet on roadsides, or in garden alleys, small gelatinous, greenish masses, more or less globulous and folded up. These are a species of *Nostoc*, a kind of organism of which it is difficult to say whether it partakes most of the animal or vegetable world.

Fig 296 Mass of Nostoc.

In studying the organisation of these curious plants, we shall follow M. Thuret in the observations he has made on *Nostoc verrucose*, which he found growing in the brooks in the neighbourhood of Paris, attached to submerged stones, upon which many individuals had massed themselves together, forming on the stone a carpet of blackish green (Fig. 296). Each Nostoc is a sort of irregular air-bag, as in Fig. 296, folded, rounded, and shut up, filled with greenish gelatinous matter, whose appearance and consistence forcibly reminds one of seed of the grape. In the bosom of a very abundant mass of this matter, we find numerous filaments, composed of spherical globules placed end to end like the beads of a chaplet, and formed of a bluish-green, granulous matter. Fig. 297 represents the sort of chaplet which occupies the interior of the *N. verrucose*, and accompanies the mucilaginous matter. When the plant is surveyed in its full development, the internal pelicule formed by the thickened mucilage is ruptured, and the green substance formed of mucilage and of chaplets is left to escape. This matter is dispersed in the water with so much the more facility that it seems gifted at this stage of its existence with a very percep-

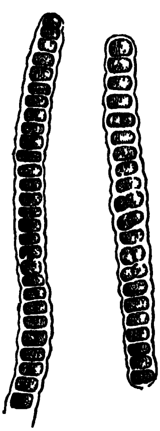


Fig. 297
Chaplet of Nostoc.

tible spontaneous movement. "In order to observe this phenomena properly," says M. Thuret, "the most simple means is to arrange some freshly-gathered specimens in a plate filled with water. In two or three days the external pelicule will burst, and the chaplets will spread themselves over the water. If recourse is then had to a microscope, it will be seen that the chaplets, originally very long and contorted in a thousand ways, are divided into numerous fragments of unequal length, nearly all straight, or only slightly flexuose, moving themselves in the direction of their length, and seeming to creep upon the plane of the object plate. Their progress is slow, but very perceptible. If the observations are continued during some days, the chaplets will become immovable, increase in size; at the same time a mucilage is developed by which they are surrounded as in a transparent frame. Sometimes the seeds considerably enlarge and divide themselves, so as to form two others, but laterally; this formation repeats itself many times, and it would seem natural to seek there for the origin of new chaplets. Unfortunately, the increase of the seeds in number, by diminishing the transparency, no longer permits us to follow their increase with the same facility."

It is obvious, then, that these plants present an organisation quite rudimentary, and that their mode of reproduction consists of a species of *segmentation*, namely, the division of the individual into new individuals, an arrangement which seems to approach the organisation of the lower animals rather than that of the vegetable world.

The *Nostoc*—in consequence, no doubt, of the extreme rapidity of its vegetation—greatly attracted the attention of the alchemists, who often mention it, and it enters into many of their recipes for the pretended transmutation of metals.

Sphæroplea annulina, belonging to the sub-family *Oscillatoridæ*, is a freshwater species, belonging to the Confervaceæ, composed of long filaments, formed of cellules more or less elongated, and associated end to end like the Nostocs. These cells consist in their adult state of Chlorophyle, a watery liquid, and some feculous granules; the whole distributed in such a manner that the liquid element forms coarse cells, arranged in straight lines. (Fig. 300, 1). Thus the *Protococcus* is an individual consisting of one cell only.

Q 2

The *Oscillatoria spiralis* is a simple vegetable thread formed by cells cohering at their extremities. The *Oscillatoria nigro-viridis*, shown in its natural state in Fig. 299, is a simple vegetable struc-

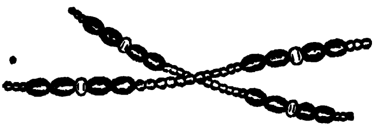


Fig. 298. Two plants of Sphærozyga Berkeleyana.

Fig. 299. Three plants of Oscillatoria Nigro-viridis.

ture, consisting of cells united at their extremities like threads. *Sphærozyga Berkeleyana* is a thread formed of simple cells touching each other at each end.

In the month of April the contents of certain small cells are modified so as to give a spongy appearance, first by the multiplication of these small cells (Fig. 300, 2), than by the condensation of the green matter and grains of starch, like the figure, 3, and by the dispersion of most of the small cells from *b* of the same figure, where the great flattened cells represent the superposed cellules. Sometimes the same cells contain a great number of free globular masses (Fig. 300, 4). These masses are young and soft spores, elastic, and destitute of membrane.

Long before the contents of these cellules have submitted to the transformations indicated, the membrane proper to the cellules presents small openings at various points, whose diameter varies from 1-300th to 1-500th part of a line (Fig. 300, 4 and 5, *o*).

But all the cellules of the same filament of *Sphæroplea* do not present the same modifications which we have described, and which are finally converted into sporanges, filled with a multitude of spores. Phenomena of a very different nature occur in the meantime. The rings interposed between the uncoloured cell become reddish, and the grains of starch which they contain disappear (Fig. 300, 5, *a*). Sometimes the orange-coloured matter is organised in an infinity of short corpuscles, arranged in a confused mass. The rings are decomposed, and suddenly one of the corpuscles is observed to plunge into their substance, disengage itself, and move in the cellular cavity; then other corpuscles in increasing numbers repeat the same phenomena. The movement

which agitates them becomes excessively animated, and in a few minutes the whole substance of the ring under observation is an

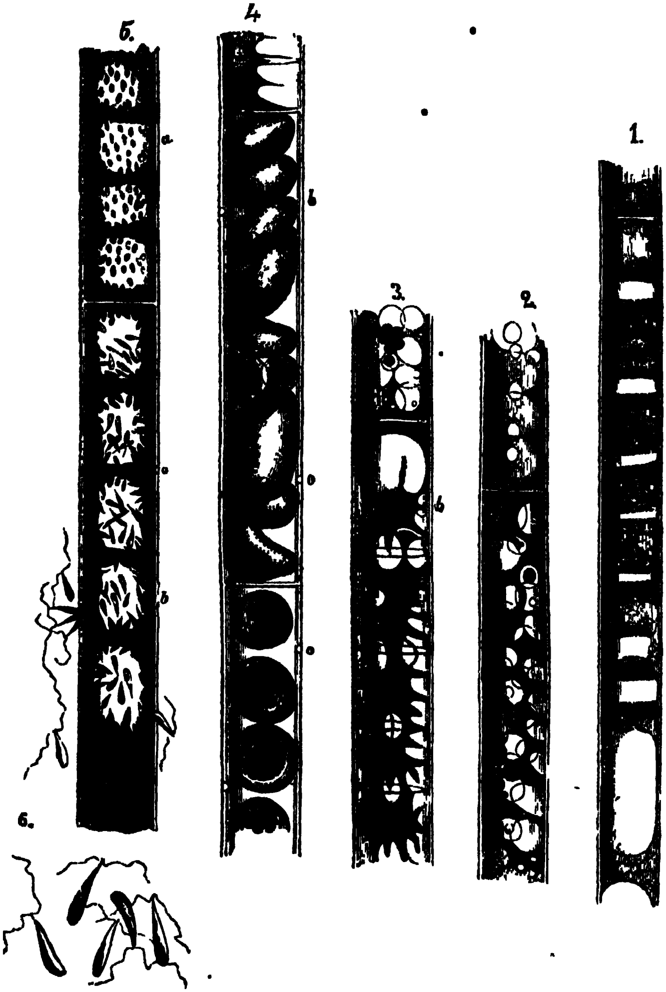


Fig. 300. Reproduction of Sphæroplea.

innumerable multitude of corpuscles. A second and a third ring of the same cellules undergo the same process, until the whole mass is filled with elongated corpuscles which move and swarm in

all directions (Fig. 300, 5, *b*). Under a very strong magnifier these moving corpuscles appear as in Fig. 300, 6. "It is," says M. F. Cohn, the Botanical Professor at the University of Breslau, to whom we are indebted for these observations, "it is a spectacle truly surprising that, amidst all these movements of incredible activity in the bosom of the mother cell, the membrane of the cell is pierced at a given moment with one or many openings corresponding in form and dimensions to those we have already seen with the cellular sporanges. A first corpuscle escapes by one of these perforations, others follow, and they soon flow in multitudes. When movement in the water is at first slow, it is often obstructed by the mucilaginous envelope against which the corpuscles press in vain. I have seen them, after struggling for twelve hours, still agitating themselves tumultuously within their prison-house, return to a state of repose, and finally be transformed into yellowish vesicles. The active corpuscles, of which we are speaking, measure about the 200th part of a line in length; their form is elongated and cylindrical, and reminds us of certain small Coleoptera. Their posterior extremity is slightly swollen, sometimes flattened and enlarged at the same time, of a yellowish tint, and granules can frequently be traced in its interior. The anterior extremity, on the contrary, is elongated into a species of straight and glassy beak, having at its extremity two long cilia, which become very irritable in a solution of iodine, which seems to destroy the corpuscles. These movements of the ciliferous corpuscles are very characteristic: they are gifted with little vital energy, they only oscillate with their beak as if groping; if they move more rapidly, they turn transversely round their median axis, as a cudgel-player would do who, holding his stick firmly by the centre, makes it whirl round his head; or, to illustrate it still more familiarly, like the cat which runs round after its own tail, without changing its place. But for the most part they describe a cycloid by a movement of progression by jerks and leaps, as it were; more rarely they advance in a right line; their natural tendency towards the light being indicated by the fact that in the drop of water in which I observed them they massed themselves voluntarily towards the edge nearest to the window."

"The exterior resemblance of these corpuscules to the Antherozoids of Vaucheria, justifies one in attributing to them analogous functions. When these antherozoids become free and diffused through the water, they reunite after a time round certain cellules, whose contents are organised like spores. They agitate the water near these cellules; they attach themselves to its walls, leaving it for an instant, then returning immediately. Finally, one of the corpuscles, approaching one of the openings existing in the membrane of the sporanges, it fixes itself there, and introduces its delicate beak. Sometimes the posterior part of its body becomes too large to pass with impunity; then we see it pushing itself on, but without relaxing the hold with its beak, contracting and making itself smaller. In short, it forces itself a passage and penetrates into the cavity of the sporange. At the same time other antherozoids penetrate in the same manner or by analogous methods. Three or four of these are often engaged at once in the same opening; the smallest pass without difficulty at the first attempt, and in their movement of translation with the liquid in which they swim in the bosom of the sporange, describe great circles, and constitute an extremely curious phenomenon. After a few moments the sporange may contain more than twenty of these antherozoids, which agitate themselves round the young spores. These are, as I have stated above, small soft spheroids, more or less completely filled with chlorophyle, and enveloped in a mucous bed, having, however, none of the characters of a cellulose membrane. The spermatozoids throw themselves one spore upon another, as if some electric attracted and repulsed them alternately, and that so rapidly that the eye can scarcely follow their movement. They are often observed to move with the same agility from one end of the sporange to the other, while the agitation of their vibratile cells impresses upon the spores a slow movement of rotation. I have seen the antherozoids agitate themselves confusedly in the cavity of the sporange during more than two hours. Their movement becomes slower and slower by degrees, and they finish by attaching themselves to the surface of the young spores. We can then see one or two fix themselves by the cilia and the beak upon each of these bodies, dwelling as if implanted there, oscillating

there for some time; then finally they become quite immovable, and attach themselves in all their length upon the spore. Their body loses its form; it is no longer a mere mucous. drop, of which a part seems to be absorbed by the spore. The primordeal spore, now fecundated, soon becomes covered with a true cellular membrane, as represented in Fig. 301."

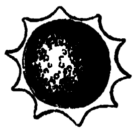


Fig. 301 Spore of Sphæroplea.

When these spores are prepared to germinate, their contents are subjected to many modifications. They become granulated, assuming a sombre tint of reddish brown, and a transparent circle shows itself in the centre. The reddish matter frequently assumes a greenish tint before germination. This change of

Fig. 302. Spores of Sphæroplea in course of germination.

colour proceeds slowly and step by step from the exterior of the spore towards the centre of its cavity, and the plastic contents finally separate, first into two, then into four, and ultimately into a much greater number of parts (Fig. 302, *a*, *b*, *c*), which rupture their double envelopes and spread themselves freely in the water, like so many zoospores.

The form of these zoospores is as uncertain as their size and colour. During more than an hour these corpuscles, furnished with two cilia to their beak, agitate themselves by a slow jerking movement, interrupted from time to time with long pauses, until it almost seems as if they had lost their power of movement, when, after many hours of immobility, they suddenly resume their motion.

When these zoospores begin to germinate they elongate themselves more and more, in a spindle-like form, swelling in the middle, as in Fig. 303, *a*, *b*, *c*, *d*, *e*, *f*. In a short time the little plant, hitherto formed of a single cell, separates into two equal compartments; then, successively, into a great number of cells, at the cost of, and in proportion to their size, becoming finally a young Sphæroplea.

Such is a brief history of *Sphæroplea annulina*, in which the descriptions of M. Cohn are only slightly abbreviated. The strange details give birth to feelings of profound admiration in the naturalist and thinker. Here are individuals placed at the bottom of the vegetable scale which are reproduced by the emission of germs gifted with a movement of their own, and seemingly guided in their evolutions by a true kind of instinct.

Looking at these voluntary movements so apparent in the younger generations of an inferior vegetable, one is drawn, with the German naturalist, to consider them as animals, which, by holding themselves immovable, and attaching themselves to some object, become vegetables. But how much do these facts overthrow the notions generally entertained of the distinctions between animals and plants! In order to know in what life consists, it is not sufficient to contemplate creatures of the higher organisation only; the whole series of creation must be contemplated, from man down to the humble *sphæroplea*.

Fig. 303.

III. Fucaceæ.

The Seaweeds closely resemble Confervaceæ both in structure and local habitat. They differ in their mode of reproduction, the organs appearing as little green warts on the outside of the plant, invested by a thin membrane enclosing the sporules; while the antheridia have a spiral filament. Some of them are used as food, as *Alaria Æsculenta*, and *Fucus vesciculosus*, which are eaten by the inhabitants of Scotland and Ireland, and the natives of the shores of the Pacific. They have also been extensively employed for industrial purposes, both in our own and other countries, in the manufacture of kelp, glass, and especially iodine, which is extracted

from many species. The *Fucaceæ* are distinguished from all other seaweeds by a remarkable characteristic, namely, the position of their spores within little hollows sunk in the substance of the plant, and communicating with the surface by a pore.

Dr. Lindley divides the order of Fucaceæ into the three following sub-orders, each distinguished by their own peculiarities:—

I. VAUCHERIÆ.	Frons mono, or pleis sephonous, without bark, the utricles forming a lateral branchlet, proceeding from the upper joint, sometimes from the lowest.	Including Hydrogastrum and Vaucheria Dasycladus, Ectocarpus, Batrachospermum, and Chordaria.
II. HULYSERRÆ.	Frond polysiphonous, barked and jointed, vesicles scattered over the surface of the frond, or in heaps.	Including the Spacelaria, the Dictyosiphon, Laminaria, and Sperachnus.
III. FUCEÆ.	Frond polysiphonous, often bladdery, vesicles seated in hollow conceptacles formed of a folding-in of the fold, pierced by a spore surrounded by flock; conceptacles scattered or collected upon a receptacle.	Including the Lemanea, Fuci, Cystoceira, Sargassum, Turbinaria, and Scirococcus.

Two species of Sargassum, *S. vulgare* and *S. vacciferum*, are frequently found on our shores as far north as the mouth of the Clyde and the west coast of Scotland; but they are mere waifs and strays cast with other tropical productions on our shores. They are the "Gulf-weed" which form floating meadows in the midst of the ocean. "Midway the Atlantic," says Maury, in his "Physical Geography of the Sea," p. 88, "in the triangular space between the Azores, Canaries, and the Cape de Verd Islands, is the great Sargasso Sea, covering an area equal in extent to the Mississippi Valley; it is so thickly matted over with the Gulf-weed that the speed of vessels passing through it is often retarded. When the companions of Columbus saw it, they thought it marked the limits of navigation, and became alarmed. To the eye, at a little distance, it seems substantial enough to walk upon." The reproductive bodies of these plants are in the beginning little wart-like bodies, invested by a very thin membrane, placed close over an inner sac filled with green granules. The spores are external; that is, they are inserted on the surface of a vescicle upon which they are generated.

VAUCHERIA.

Tufts of Vaucheria are formed of a network of cylindrical filaments, branching and continuous, enclosing green granules and a colourless mucilage. This small plant, common enough in marshy places, is rendered very remarkable by its diverse modes

of reproduction. It has been the subject of most interesting and minute investigations made by M. Thuret and Von Pringsheim. Its reproductive spores are, as we shall see, gifted at one period of their existence with a true movement, and it may actually be said to walk. This very remarkable fact shows how difficult it sometimes is to establish precise differences between plants and animals, and to define absolutely the limits of what are sometimes called the kingdoms of nature.

The extremity of the filaments of this *Fuci* are swollen into a club-like form, and the green matter is condensed there until

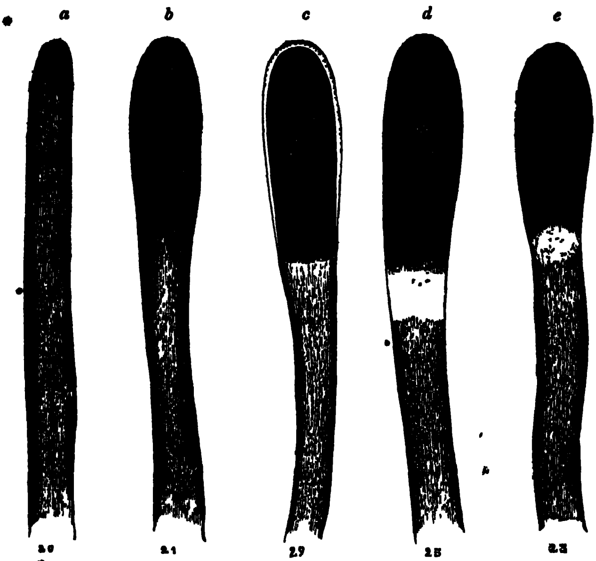


Fig. 304. Transformation of Vaucheria.

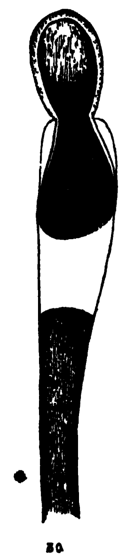


Fig. 305. Spore of Vaucheria escaping.

it assumes a blackish tint. In Fig. 304 are represented the successive alterations which the extremity of *vaucheria* presents at the moment when the work of reproduction is in progress. The letters *a b c d e* indicate the progressive modifications which take place. According to M. Thuret, the granules separate themselves slowly, the one from the other, towards the base of the club-like swelling, leaving there a vacant space. The granules now approach each other again, and once more form a junction. But then a great change takes place, for this singular operation

seems to determine the separation of the mother plant from the reproductive body or *spore*. Henceforth the spore is invested with a proper membrane, and possesses a distinct organisation. This is the moment when the crisis approaches. The upper extremity of the spore is ruptured (Fig. 305); at the same time it begins to turn on its axis so completely that the granules contained may be observed passing rapidly from right to left, and from left to right, as if they moved in the interior of a transparent cylinder. The narrow opening by which the spore seeks its egress produces a very marked state of strangulation. In a few moments it succeeds in disengaging itself and throws itself into the water.

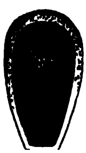


Fig. 306.

Once detached from the mother, the individual spore now, as represented in Fig. 306, continues to turn upon itself unceasingly, but with a very irregular motion, its movement being now quick or slow in one direction and now in another. Generally it gains the edge of the object-glass on which the observation is being made as if it sought to escape from its prison-house. Sometimes its motion is arrested for an instant, and immediately it resumes its more active career.

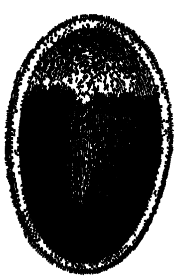


Fig. 307. Spore with its Cilia.

The whole surface of the spore is covered with vertibratal cilia, Fig. 307, which, however, are quite invisible from the rapidity of their motion. In order to see them properly it is necessary to stop them by means of some re-agent, such as opium or iodine. The effect of this application is very remarkable. The opium reduces the movements of the spores of the Vaucheria so as to admit of the play of the organs being quite perceptible. The iodine arrests them suddenly, and makes their motion more perceptible from the suddenness of their arrest. The iodine employed by M. Thuret contained only one thousandth part of iodine.

This gentleman has succeeded in following the movements of a spore of *Vaucheria* in water during more than two hours. When the cilia finally cease to move, the spores remain immovable and soon begin to germinate (Fig. 308), giving birth to a *Fuci*, a new *Vaucheria*.

Here we are permitted to behold a very astonishing phenomenon. Are these young beings really plants? The German botanists call them *Zoospores*. They identify them with animals, remarking that animals only have organs of locomotion, and that the *vibratile cilia* which are observed in the spores of the *Vaucheria* are true organs of motion. Thus, according to certain German naturalists, at the commencement of their lives these *Fuci* are true animals, which only become plants when they are fixed and begin to germinate.

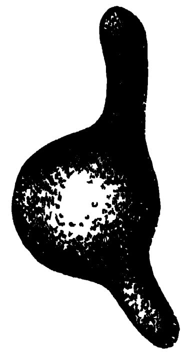


Fig. 308. Young Vaucheria.

Apart from this theory of transformation, Unger's remarks upon the clubbed Vaucheria, *V. Clavata*, are highly interesting. While examining this plant he found that the vesicular summits had the power of contraction, and that by this process they expelled the contained sporules, which, after expulsion, ascended to the surface of the water. Happening to look at the surface of this water, he was surprised to find it covered with small globules of unequal size, swimming freely here and there, and gliding round globules that remained motionless, stopping and again setting themselves in motion, like animated beings. The next day a great number of these globules aggregated round the bubbles of gas disengaged from the *Confervæ*, and floated at the surface,—some dark green, others round or elongated, others transparent, humid, diverging at right angles with each other, all evidently plants in a state of germination. Other globules were oval, dark at one extremity, and almost transparent at the other, which swam freely about, and within the space of an hour he succeeded in tracing not only the diminution of vitality and the death of these *infusoria*, but the subsequent development of the dead animals into germinating plants.

The French botanists are more cautious in expressing their views; they dare not pronounce upon the animality of these beings; and the researches of M. Decaisne prove beyond a doubt the vegetable nature of the so-called zoospores, a doctrine to which the more eminent English philologists had long given their adhesion. For ourselves, we confine ourselves to this brief explanation of both opinions.

When the spore has become fixed, it develops itself regularly;

its progress is easily followed under the microscope. The elongation of the filaments takes place, so to speak, under the eye. M. Thuret states that he has measured more than once an increase of three-twentieths of a millimetre (about three-eightieths of an inch) in an hour.

Besides these non-sexual multiplications by zoospores, there has been recently discovered in the same plant a true sexual reproduction, produced by the assistance of two distinct organs, borne at a little distance the one from the other on the filaments. The one (Fig. 309, A) is a sort of short branch, re-curving as it were upon itself, like a snail, or small horn. The other, B, is a sort of shell, light and thin, and fashioned like a beak, which is called the *sporange*. These two organs are separated, the one from the other, upon the tube which carries them, by a transverse chamber. In the interior of

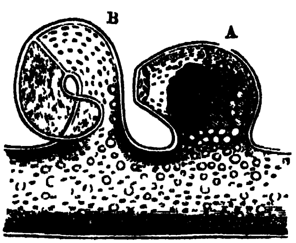


Fig. 309. Sporangia of the Vaucheria after fecundation.

the sporange, and towards its base, certain green seeds are found, while towards the beak is a colourless matter, very finely granulated. At the extremity of the cornicule, which is bounded by a thin partition, a great number of small clubs are found, more or less surrounded by a colourless mucilage.

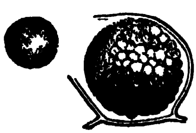


Fig. 310. Antherozoid of the Vaucheria.

Such is the state of things when fecundation takes place. At this moment the membrane of the sporange is broken at its tip, and the matter contained in this species of sac is poured out through the opening (Fig. 310). Immediatety after the sporange opens, the cornicle, by a marvellous coincidence, opens also at its extremity, and pours out its contents. Innumerable corpuscles of minute size, but retaining their club-like shape, that is to say, *antherozoids*, now issue from the cornicles. They penetrate the adjacent opening of the sporange (Fig. 311), filling it almost entirely. Arrived at the surface of the mucous and granulous bed, which prevents them, by its consistence, from penetrating further, they advance and retire, continuing this


Fig. 311. Antherozoids penetrating the Sporangia.

backward and forward motion during the next half hour, presenting a most singular spectacle to the observer. Sometimes a partition is formed in advance of the mucous bed, which prevents the ulterior action of the locomotive corpuscles from exercising themselves upon it. These movements will endure for yet another hour; but they become gradually slower and slower, ceasing entirely at the end of a few hours.

It is after the introduction of the *antherozoids* into the sporange that a large cell or spore forms itself in the interior of the sporange, which completely fills it. At first greenish, this cellule becomes paler by degrees, and presents in its interior many larger bodies of a sober brown (Fig. 312). Sometimes it is isolated from the tube in consequence of the membrane of the sporange beginning to decompose. At a certain time, that is, in about three months, this spore begins to recover its green colour; it becomes elongated slowly, and soon assumes the form of a young tube of *Vaucheria*, and in a short time it is a perfect resemblance of the mother plant (Figs. 313 and 314).

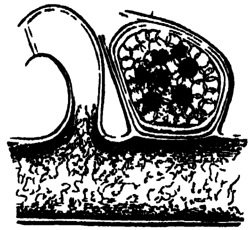
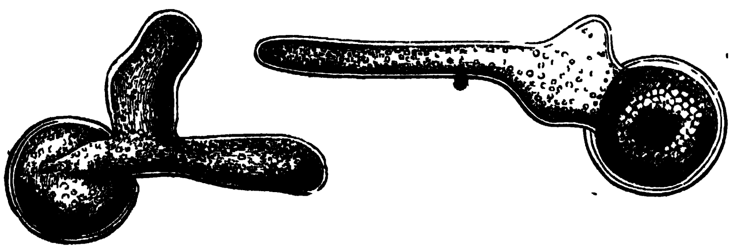


Fig 312. Formation of Spores



Figs. 313, 314. Spores of Vaucheria germinating.

Such is the double and singular mode of fecundation in the *Vaucheria*. It was foreseen by Vaucher, who recognised the first, and suspected the importance of the cornicles; but we are indebted to Von Pringsheim, an able German anatomist, for the complete and circumstantial relation which is here presented. The *Fucus vesiculosus* (see Fig. 315) is the commonest and best known of all the Marine Algæ. It is found on all the shores of Europe, and

in the North Sea it grows so abundantly that it is used for domestic purposes, such as roofing houses. It is also cut twice a year in some places in order to extract soda from its ashes after burning it. The plane part of its bifurcated frond is sown with

Fig. 315 Fucus Vesiculosus.

globulous vesicles or air-bags, which are probably intended to sustain the plant in the water and perform the functions of the air-cells in fishes. Certain mamelous tubercles invest the extremity of the bifurcations of the frond.

If the water is withdrawn from certain portions of the plant at the time when the tubercles are fully developed, it is sometimes observed that their orifice is closed by a drop of reddish liquid, while other portions of the same plant present in similar circumstances a sort of secretion, no longer red, but olive.

This change of colour seems at first glance to indicate a physio-

logical difference in the tubercles borne upon the different fronds. The fact seems to be that each of these tubercles is only a cavity or conceptacle, enclosing in the one case a fecundating apparatus, in the other a fruit-bearing organ; and these organs are borne upon separate tubercles. *Fucus vesiculosus* may therefore be considered as *diœceous*. "The fructification of the Fucaceæ," says M. Thuret, "is contained in small spherical cavities situated beneath the epiderm, called conceptacles. These are completely closed at first, but open eventually; they open at the surface of the frond by a small pore or mouth, through which the reproductive bodies escape, assisted by jointed and branched hairs or cilia, which line the conceptacle which supports the antheroids, and it is at their base that the spores are fixed. In certain species, spores and

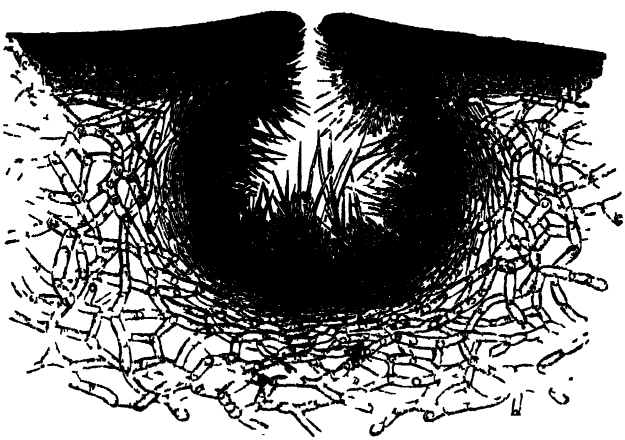


Fig. 316 —Transverse section of the Conceptacle.

antheroids are found in the same conceptacle; in others, on the contrary, these organs are produced in different conceptacles, and on different individuals."

The male conceptacle of *F. vesiculosus* (Fig. 316) is found to contain small ovoid, transparent sacs, containing a whitish mass sprinkled with reddish granules. These are the *antheroids* which are inserted or supported upon the branched reticulated hairs which line the conceptacle. They enclose numerous transparent corpuscles, at first very thin and colourless, but in time the

matter condenses into little bodies forming a greyish mass, sprinkled with orange or reddish spots. These corpuscles are the antherozoïds, which are so packed that neither form nor structure can be recognised. The antherids of Fucus, Ozothallia, Pelvetia, and Himanthalia have a double envelope; that is, the sac in which they are contained is itself closed by another of the same description, which remains fixed to the hair on which it was produced, while the inner one is expelled through its summit and falls into the conceptacle, whence it glides as far as the mouth. The antherozoids which fill it soon become violently agitated; the sac opens at one or both ends, through which they force their way into the stamen and disperse. In Halidrys, Pycnophycus, and Cystoseira, the second envelope is absent, the mere sac only is found attached to the jointed hairs, and the antherozoïds are expelled directly and in a mass, remaining for a time in ceaseless struggling, and turning upon one another before dispersing in the liquid, where they move with great vivacity. Their locomotive organs consist of two cilia, greatly attenuated, the shorter of which appears to be inserted at the smallest extremity of the body, which is always in advance during its progress. The second cil is drawn behind the corpuscle.

In what some botanists designate the female conceptacle of *Fucus vesiculosus* (Fig. 317), certain membraneous sacs, more or less spherical or ovoid, are found, enclosing a rounded opaque mass, of a greyish brown, divided into eight parts. These sacs or sporanges are borne upon a short peduncle, and surrounded by articulated filaments. When the sporange opens, as the antherozoïd does at a given moment, the mass which it contains is set at liberty, still preserving its original form, so long as the inner sac is sufficiently strong to restrain it. But matters do not remain long in this state; the spores isolate themselves more and more in the membraneous envelope which confines them, and finally they become free. They are then perfectly round, of an olive yellow, and absolutely destitute of skin.

M. Thuret, to whom we are indebted for some excellent observations on the structure of these vegetables, has established by his experiments what becomes of the spores when disengaged from their envelope. "If the male fronds, which are easily recognised

by the yellowish colour of their receptacles," he says, "are placed for a short time in a humid atmosphere, an effect is produced analogous to what has been described in the female. The antherids, expelled in immense quantities from the conceptacles, form on the surface of the frond at each *ostiole*, or mouth, small viscous mammals of an orange colour. When a portion of the viscous matter is detached with a needle's point, and examined with

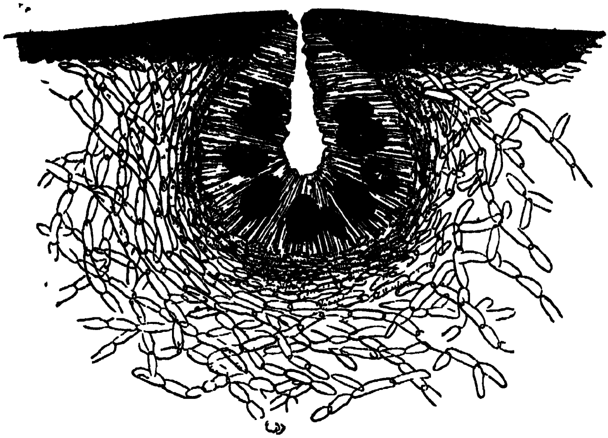


Fig. 317.—Transverse section of the Conceptacle enclosing Sphores.

the microscope in a drop of sea-water, it is seen that it is entirely composed of antherids, which almost immediately discharge the antherozoids which they contain. These move about with the utmost activity, and their movements are prolonged sometimes till the next day, diminishing in their intensity, however, and by the third day at latest they have become decomposed.

"In order to fecundate the spores and prepare them for germination, it is necessary to mix them with the water which contains some antherids. If the experiment is made upon a glass plate, and the antherozoids are present in considerable quantities, one of the most curious spectacles which the study of these interesting plants can produce will be presented to the observer. The antherozoïds, attaching themselves in great numbers to the spores, communicate to them, by means of their vibratile ciliæ, a movement of rotation, sometimes very rapid. Sometimes the entire field

of the microscope is covered with these thick brownish spheres, bristling with antherozoïds, which roll themselves about in all directions, surrounded with swarms of these corpuscles.

"In about half an hour, rarely longer, this movement of the spores ceases; the antherozoïds continue, however, to be agitated for some time, but with diminished activity, until all movement is finally arrested. From the day when the spores are thrown into contact with the antherozoïds they are already re-invested with a membrane."

Fig. 318. Fucus Nodosus.

M. Thuret remarks on this movement of rotation among the spores, that the phenomenon, however curious, does not perhaps merit much consideration. He does not think it necessary to the fecundation of the spores, and does not admit that the movement takes place in nature.

IV. Ceramiaceæ.

Seaweeds are distinguished by their rose or purplish, sometimes olive or violet colour, hence called Rose-tangles. They are cellular, or rather tubular, unsymmetrical bodies, their cells being long and tubular, occasionally only polygonal, multiplied by means of tetraspores and sphærospores, as they are in threes, as in Chondria, or fours, within a transparent perespore, as in *Corallina officinalis*, or mother-cell; a variety in their fructification which, as Dr. Lindley remarks, "seems to indicate their being the highest form of algals." They are entirely marine species, and, according to Endlicher, they chiefly abound between the 35° and 48° parallel, diminishing in number towards the pole and the equator, and being rare in the Southern hemisphere. It is among the genera of this order that the more gelatinous seaweeds occur: the material out of which the swallows construct the edible nests so valued by the Chinese is supposed to be Gelidium. *Plocaria compressa* and *Chondrus crispus* possess similar qualities.

Rhodomenia palmata, the Dulse of the Scottish coast, the Dillesk of Ireland, and the Saccharine Fucus of the Icelanders, is eagerly sought on the coasts throughout the maritime countries of Europe.

V. Characeæ.

The Charas are aquatic plants, composed of an axis consisting of parallel tubes, which are either transparent or incrusted with carbonate of lime, and of whorls of symmetrical tubular branches, multiplied by spiral-coated *nucules* filled with starch. They are among the most obscure creations of the vegetable world in regard to their reproductive organs, but their transparency makes them interesting objects of investigation, and they were the first in which an actual circulation of sap was observed. They inhabit stagnant fresh or sea waters, and live always immersed, giving out a fœtid odour, and having a dull greenish colour. Their stems are regularly branched, brittle, and surrounded here and there by smaller branches or whorls, the axils of the uppermost whorls, concealing the reproductive organs, consisting of *nucule*, supposed to be analogous to the pistil, and a *globule* representing the anther.

The order consists of three genera, Chara, Notilla, and Charopsis; the first containing on the outsides of its central tube a thick layer of calcareous matter, which is the result, according to Greville, of the peculiar economy of the plant itself, and according to Brewster, analogous to the siliceous deposit on Equisetum. Notilla, on the contrary, is transparent, and free from all foreign matter. This property seems to have recommended it as a subject for experiment. It appears that if the stem of any transparent Chara is examined with a good microscope, a distinct current will be seen to take place in every tube of which the plant is composed, setting from the base of the tubes to the apex, and returning in *C. vulgaris* at the rate of about two lines per minute, and that this movement is destroyed by the application of a few drops of spirits; by pressure; or by lacerating the tube. M. Thuret's account of the structure and action of these plants is singularly interesting. "The antherids in all the species are in the from of orange-red globules, immediately below the spore-cases. These globules consist

of eight slightly concave triangular cells, crenellate at the edge, the crenells dove-tailing together so as to form a sphere when united with a corresponding partition directed towards the centre of the cell, occupying about a third of its breadth; that part which is turned towards the antherid is clothed with a lining of red granules, the rest of the cell containing a colourless liquid which gives it transparency, and produces the appearance of the antherid being surrounded by a whitish ring. To the centre of each cell is attached an oblong vesicle filled with orange-coloured granules arranged in lines, and presenting a very remarkable circulation. The eight vesicles emanating from the eight cells converge in the centre of the antherid, where they are united by a small cellular mass; while a ninth vesicle of the same nature, but larger and bottle-shaped, fixes the antherid, its broad base being attached to a branch of the plant, while its other extremity, penetrating the four lower valves, is fixed in the central cellular mass of the antherid. From this point also are a number of wavy transparent tubes divided by partitions, in each joint of which is borne a thread-like anthozoïd rolled up on itself several times. When these tubes are young their joints contain only a small granular mass forming a nucleus of oval form and greyish colour, of irregular form and higher refractive power, as well as more defined edges at the base. This nuclei subsequently disappears, leaving a brilliant point encircled with black on each side of the joint. This is the first indication of the appearance of an antherozoïd, and it is produced by the circumvolution of their thread-like body. By degrees the antherid dehisces; the valves or cells turn back on the branch, dragging with them the oblong central vesicle, to the extremity of which a portion of the cellular mass adheres, which bears the tubes filled with antherozoïds. These now present themselves, under the microscope, twisting and turning in all directions in the cavity which contains them. They eventually escape by a sudden movement which resembles the action of a spring. When free they resemble a thread twisted up into a corkscrew form with three or four turns, like the fragments of spiral vessels. The field of the microscope is quickly covered with little thread-like bodies swimming with a singular tremulous motion. They turn upon their axis, always preserving the screw form, for their spiral

seems to be somewhat stiff. Their motion seems to be caused by the continual agitation of two long ciliæ of excessive fineness which spring from behind the anterior extremity of the spiral on which they seem to fold themselves. The posterior extremity, namely, that which is dragged along by the advancing antherozoid, is granular, thicker, and less defined than the rest of the body. When the ciliæ diminish in activity, it is easy to see that motion originates at their base and extends by waves in the direction of their length. Iodine, alcohol, ammonia, and the acids, stop these movements, the ciliæ resisting the action of ammonia longer than the other parts of the antherozoids." The phenomena which he has described M. Thuret considers unquestionably of the same nature as in the Mosses, their function being, as he believes, impregnation; for which purpose the spore-cases seem to be constructed, being surmounted by five cells surrounding a small canal, when young forming a sort of stigmatic coronal, which disappears at a later period when the reproductive body has arrived at a certain stage of growth.

Fungales.

The Fungi, or Mushrooms, form an extensive section of Thallogens. Their best known form is the Mushroom, in which we recognise the true sporidia, contained in asci or sporule cases as the organs of reproduction. But it includes forms of infinite diversity, the least noticeable of which perhaps are the minute substances which appear in and upon decomposing fluids, and as vegetable parasites upon many living animals and plants. All alike, however, consist exclusively of cellular tissue, although they differ widely in their arrangement, and especially in the nature of their reproductive organs. In the more minute bodies just alluded to, the organ of fructification is simply an enlarged asci containing the spores. But in the Mushroom the sporidia are contained in a sporule case, and in some others there are movable sporal fibres or elaters. They vary widely in form, size, colour, and duration; but one of their most common characteristics is rapid growth and brief duration. The most conspicuous species are distinguished by elegance of shape and bright glossy colours. But

nothing can exhibit greater extremes of development if the highest and lowest forms of Fungales are contrasted: the large fleshy *Boletus*, for example, which grows on the trunks of trees, and the microscopic mould-plant, composed of threads much too delicate to be distinguished by the naked eye, although the latter proves to be only a simpler form of the former. Viewed in their whole extent, the Fungales may be described as cellular flowerless plants, nourished through their thallus or mycelium; having a concentric mode of development; living in the open air; propagated by spores, colourless or brown, and sometimes enclosed in asci—that is, in transparent cells—and destitute of gonidia.

The Fungales are very extensive as regards genera and species. The Rev. Mr. Berkeley gives the number as 598 genera and 4,000 species, to which new forms are being constantly added. "In their simplest forms," says Dr. Lindley, "Fungales are little articulated filaments, composed of simple cellules placed end to end. Such is the mould found upon various substances—the mildew of the rose-bush, and all the tribes of *Mucor* and *Mucedo*. In some of these the joints disarticulate and appear to be capable of reproduction; in others, spores collect in the terminal joints, and are finally dispersed by the rupture of the cellule that contained them. In a higher state of composition they are masses of cellular tissue of a determinate figure, the whole centre of which consists of spores attached, often four together, to the cellular tissue, which at length dries up, leaving a seed-like mass, intermixed more or less with flocci, as in the puff-balls, or sporidia contained in membraneous tubes or asci, like the thecæ of Lichens, as in the *sphærias*. In their most perfect state they consist of two surfaces, one of which is even and imperforate, like the cortical layer of Lichens; the other, separated into plates or cells, and called the *hymenium*, to whose component cells, which form a stratum resembling the pile of velvet, the spores are attached by means of little processes, and generally in fours, though occasionally the number is more or less."

Schleiden's account of the reproductive process of Fungales is highly interesting. The most simple filamentous Fungi, the *Hyphomycetes*, form, "at the end of the thread-like cells," he says, "narrow protuberances, on each of which a spore is developed;

this at length separates, having a double membrane, the cell of the spore itself, and the covering or sporangium arising from the parent cell in *Penicillium* and *Botrytis*. In others, the thread-like cells form a spherical swelling at the extremity, from which project a number of such prolongations, each of which contains a spore, which forms a divided sporangium, as in *Mucor* and *Penicillium*.

"In others, as in *Gasteromycetes*, the ventricular Fungi, the thread-like cells, combine into pointed and non-pointed, variously-shaped sporocarps, in or upon which are spores of the development of which we know nothing. After the scattering of the spores the thread-like cells often remain as tender wool, as in the *Trichiaceæ*, or as delicate net-work (capillitum), as in *Stemonitis Cribrarea*, and the external capsule, generally composed of fine filamentous cells, is then dissolved or ruptured in a regular manner, as in *Arcyria* and *Geastrum*.

"In the most highly developed species, the *Hymenomycetes*, or membraneous fungi, elongated pouch-like cells combine so closely side by side as to form a membrane or hymenium. Some of these enlarge and become sporangia, sending out from one to six points at their free extremity, on each of which a spore is developed. Thus the filiform cells either form round masses closed in all round, called sporocarps, with cavities in their interior, or they form definitely arranged columns in *Merisma* tubes in *Polyporns*, or lamellæ in *Dædalea* and *Agaricus*, or clothed on the hymenium, as in the *Hymeniumcetes*. In *Agaricus* the law of their development is pretty well understood. At definite points of the flocculent mycelium, small hollow heads (volvæ) are formed, at the bottom of the cavity of which there grows a corpuscle, pedunculated below, and enlarged into a sperical form at the top. In the lower part of this protuberance a circular horizontal cavity is formed, to the upper surface of which are attached the tubes, lamellæ, &c., which bear the hymenium. The bottom of the cavity is only formed by a membrane (indusium), separated from the pedicel on its further development; or loosening itself at once from it and the upper part at the same time, it remains as a membraneous ring upon the stalk. The upper part, which supports the hymenium on its lower surface, dilates subsequently, and appears as an umbrella-like expansion,

called the cap (pileus). The whole then breaks through the volvæ, which is very soon dissolved."

A most formidable array of Fungales (*Entophyta*), which are parasites on man and living animals, can be produced. Still more numerous are those which infest fruits and vegetables. Smut in wheat, and other cereals, is produced by *Uredo segetum;* rust, red gum, red rag, is produced by *Uredo rubigo;* mildew is caused by *Puccinia graminis* enlarging the stomato of the plant. The potato disease, which caused such distress in many quarters of the globe a few years ago, is due to the attack *Botrytis infestans;* the spores of which, according to Berkeley, are supposed to enter the stomato of the leaves, causing disease in them, which afterwards extends to the tubers. The dry-rot in timber is another form of *Fungi.*

Fries, whose great work is the foundation of most of the modern arrangements of this immense family, separates them into four great divisions, which he calls Cohorts, and each of these he again divides into four sub-orders, distinguished by the following characteristics:—

Cohort.	Characteristics.	Sub-orders.		Examples.
I. Hymenomycetes.	Having a Hymenium or opening into a fructifying membrane, in which the spores or seeds are placed usually inside of a transparent simple case or asci. Texture wholly filamentous.	I. Pileati.	Hymenium on under side.	Agaricus.
		II. Elvellacei.	Hymenium on upper side.	Morchilla.
		III. Clavati.	Hymenium on both sides.	Clavaria.
		IV. Tremellini.	Hymenium confounded with receptacle. No asci, membraneous or gelatinous.	Dacrymyses.
II. Pyrenomycetes.	Fungus closed up by a Perithenium; then perforated, and closing a kernel-holding asci. Texture slightly cellular, the stroma or the receptacle somewhat filamentous.	I. Sphœriacei.	Kernel filled with asci and delequescent.	Cucurbitarea.
		II. Phacidiacei.	Kernel dry and filled with asci.	Cinangium.
		III. Cytisporei.	Kernel filled with naked spore cases.	Sphœracema.
		IV. Xylomacei.	Kernel filled with naked spore cases, and dry.	Actinothyrium.
III. Gasteromycetes	A Peridium present, closing up the fungus at first, and containing loose spores having no asci. Texture cellular.	I. Angrogastres.	Spore cases immersed in a receptacle distinct from peridium.	
		II. Trichospermi.	Spore cases naked, among filaments distinct from peridium.	Sclerodermia.
		III. Trichodermacei.	Spore cases naked, covered by filaments forming a peridium.	Spumaria.
		IV. Saleratiacei.	Spore cases immersed in a receptacle or peridium.	Chætomium.

COHORT.	CHARACTERISTICS.	SUB-ORDERS.		EXAMPLES.
IV. CONIOMYCETES.	Spores naked; texture between filamentous and cellular; the thallus often imperceptible.	I. Tubercularini.	Spore cases plunged in an entangled receptacle on a free one.	Fusarium.
		II. Mucorini.	Spore cases on a filamentous receptacle, at first inclosed in a little peridium	Stilbum.
		III. Macedines.	Spore cases at first concealed by filaments	Aspergillus.
		IV. Hypodermi.	Spore cases springing from under the cuticle of trees.	Exasporium.

MUSHROOMS (AGARICS).

The Mushrooms, then, are leafless, stemless, and rootless; they respire, thereby producing carbonic acid, like flowers and animals.

The organs of vegetation and those of reproduction are quite distinct in the mushrooms. The first are composed of a sort of packing, consisting of very thin intercrossing filaments, which are termed *Mycelium.* This mycelium is subterranean, not very apparent, and often doomed to immediate destruction. It is upon the mycelium that the apparatus of reproduction, so closely connected with the organs of vegetation, develops itself. This multiplicity of reproductive organs is recognised in certain species of which we shall have occasion to speak. The *Erysiphæ,* which attack the Pea, and the *Oidium Tuckeri,* which attacks the Vine, is supposed to be a particular state of Erysephes, in which are noted three distinct kinds of reproductive apparatus, which develop themselves in succession.

Mushrooms exist under the most opposite conditions, and in every kind of locality. Some appear on the surface of the earth, as the cultivated Mushroom, the edible Boletus, the Morel, the Puff-ball, &c. Some grow upon the trunks of trees, upon branches, and upon leaves; others, as the Truffle, are found buried in the earth at a considerable depth. Thousands of small species live as parasites upon other plants; the *Oidium Tuckeri* on the Vine, *Botrytis infestans* on the potato. Others attack animals. No one is ignorant that the malady which destroyed so many silkworms in the nurseries in the south of France was produced by a Fungi which developed itself in the interior of the living larvæ. In short, these microscopic and encroaching objects attack even the skin

and mucous membrane of man and animals, producing new and dangerous diseases.

Mushrooms in many countries are a source of nourishment to the poor, who look for their return as a providential manna. But others conceal a mortal poison. Animals, such as worms, insects, and snails, feed upon them. It is not, therefore, without reason that beneficent nature has scattered them with so much profusion over the globe. It would be out of place to enter here upon an elaborate consideration of Fungales in general. We must therefore limit our remarks to some types selected from the best known in their scientific connections, or which interest us from th[e] utility, or from the dangerous maladies to which they give birth.

Fig. 319.—Agaricus Campestris.

The Cultivated Mushroom (*Agaricus Campestris*). This species, commonly raised for the table (Fig. 319), consists of footstalk or *stipe*, ranging from an inch and a half to two inches and a half in height. When young, they resemble little snow-balls, usually called Button Mushrooms. Afterwards, when the stalk appears, the cap

separates, and it becomes convex, or slightly conical, of a white or palish yellow, with rose-coloured gills, and a thick white fleshy cap. At a more advanced age the cap becomes concave, the colour grey, and the gills nearly black. A whitish membrane, like a species of veil, entirely covers the young gills, forming afterwards a sort of collar, more or less perfect, round the stalk.

The field mushroom grows naturally upon the grass sward, where it is exposed to the sun. It is also obtained by culture in dark places where there is heat and moisture, as in caves and quarries. But it is necessary to guard against its being confounded with other species which are dangerous poisons; such are the Fly mushroom, *A. muscarius* and *A. virosus*, and a species of *Amanita*, which somewhat resembles it, although it is distinguished by the footstalk being bulbous at the base, enveloped as by a purse (*volva*), and by the colour of its gills, which are not rose-coloured, as in *A. campestris*, but of a pale whitish colour. That we may have some exact idea of the structure of the mushrooms in general, let us consider the structure of the comestible species.

Let us detach one of the laminæ or gills which occupy the lower face of the cap.* We shall readily observe, by looking at it through a lens, that the two surfaces are of a velvety texture; but it is only through the microscope that their true organisation can be appreciated.

If a transverse incision is made in the thinner parts of these laminæ, which shall be perpendicular to their surface, we may assure ourselves ocularly that each plate presents three very distinct beds. A middle bed in connection with the substance of the cap—a sort of layer, upon which the perpendicular elements of the two other beds rest. These elements consist of cells of three distinct kinds (Fig. 319, 4). The first are shorter than the others, carrying nothing at their free extremity: the next are a little longer, terminating in four points, which each bear a small spherical sac at their summit (Fig. 319, 5). The third are much larger, but have neither point nor sac at their extremity.

We are assured by experiment that the little sacs, disposed in fours at the summit of the centre cells, are the reproductive organs which germinate and reproduce the mother plant. We call them *spores*; the cellules which support them are called *basides*. The

result of the germination of these spores is that *mycelium* of which we have already spoken as being the reproductive apparatus of the fungi, which are seen in the form of filaments at the foot of the mushroom in Fig. 319, 1. Fragments of this mycelium can multiply the plant much as a fragment of rhizome of a phanerogamous vegetable does. It is on this principle that gardeners sow the mycelium, which they term mushroom *spawn*, and which may be preserved for many years without losing its germinating properties. In cultivating mushrooms a hotbed is prepared, consisting of horse-dung, covered with a bed of earth of about three feet thick, in which the mycelium is planted, watering it from time to time in order to maintain a certain degree of humidity. In a short time small tubercles will appear, which at a later period become young mushrooms.

The Truffle, belonging to the sub-order of Gasteromycetes, asserts its fungale characteristics by its membraneous sporangia, which are scattered on a serpentine vein-like hymenium, and enclosed in a concrete uterus. The sporidiæ are at first pulpy. There are two genera: *Tuber*, the common truffle, and *Rhizopogan*, the white truffle, the species being very generally diffused over the temperate parts of the globe, growing ten or twelve inches beneath the surface of the soil. The *Rhizopogans* have a sessile uterus, bursting irregularly, and marbled internally with anastomosing veins and sessile sporangia; the *Tubers* a closed uterus, marbled internally with veins. The sporangia are pedicillate and confined to the veins.

The Common Truffle (*T. cibarium*) is of irregular form, nearly black in colour, and warty in appearance. It seems to affect the soil covered with woods, especially oak and beech woods, but there is no reason to suppose that there is anything approaching a parental bond between the truffle and the roots of trees among which it grows by preference. It develops itself as others of the mushroom tribe do, by *spores*, which make their appearance in the matured plant. They are singularly small, something less than the three-hundredth part of an inch in diameter. When the truffle is left after maturity to decompose in the sun, these spores produce whitish filaments. analogous to the mycelium of the Agaraceæ. This mycelium, when buried in the soil, in due time reproduces the truffle.

If we examine the soil of a truffle bed of Poitou, in the month of September, for instance, we find that it is traversed by great numbers of these white cylindrical threads, as fine as a sewing-thread, which are nevertheless composed of microscopical filaments some thousandth part of an inch in diameter. These threads, notwithstanding their minuteness, are formed of cellules, and in continuation with a flaky mycelium of the same nature, which surrounds the young truffles, forming round them a sort of white packing, some twentieth part of an inch thick. These filaments connect themselves directly with the external bed of the young truffle. But this enveloping network is soon destroyed; at first slowly and partially, then entirely, and the truffle appears completely isolated in the soil.

The structure of the truffle is much more complicated than was formerly imagined, and we are indebted to the works of the Brothers Tulasne for much that we now know respecting the organisation of this singular vegetable.

The young vegetables present very irregular sinuous cavities, partially communicating with each other, which abut, sometimes on an unique opening corresponding to an exterior depression, sometimes on many points of the surface. When more advanced in age they are traversed by a double system of veins—the one white, the other coloured. The coloured veins are continued to the exterior tissue which composes the envelope. In their middle parts they are formed of a network of filaments running also in the same direction, whence issue shorter filaments perpendicular to them, whose swelling extremities become the *sporangia*. The white veins seem to be forced by the elongation of sterile filaments intermingling with the sporangia, between which the air is found to interpose itself. They come out on the surface in one or many points.

The spores, whose forms are much varied, though constant for the same species, are limited in number, which rises from four to eight. Their external membrane is soft, downy, or reticulated.

The *Tuber brumale*, *milanosporum*, *æstivum*, and *mesentericum*, are the only species sought for in France. *T. cebarium* grows abundantly in various parts of England, where it is gathered about the size of a large walnut, having a peculiar smell, and something

of the flavour of the mushroom. In Algeria *T. leonis* occupies the place of all the truffles of Western Europe. The large truffle, *Mylitta Australis*, which attains a weight of more than two pounds, is known by the natives of those regions as native bread.

The truffles especially affect a calcareous soil, or a mixture of clay and chalk. In France they abound in Poitou, Touraine, the Vivarais, the Comtat-Venaissin, Provence, at Brives and at Cahors. They require for their full development a shaded soil, rendered fertile by the decomposed leaves and fruit which annually fall from the sheltering trees; at the same time it must be separated from the subterranean network of the roots. The oak and elm are the trees most favourable to its growth. The truffle is sought for by hogs trained for the purpose, but it seems to be only out of obedience to its master. Having indicated the spot by slightly scratching it, it generally leaves to man the labour of digging it out of the earth; but if the soil is sufficiently permeable, it does not pause in its scratching until it has seized the truffle. In Burgundy the sheep-dog, and in Italy the water-spaniel, is trained and employed for the purpose. But dogs only seem to hunt the truffle from love of, or obedience to, man. The hog is more given to egoism; he loves the truffle, and hunts it out for his own use. The trained hog when on the traces of one, is immovable, with nose over his prize, waiting till it is dug out. Nor does he wait long, but seizes and devours the odorous prey himself, with the least possible delay. In Upper Provence a hog trained to truffle hunting is worth two hundred francs.

The Morel, *Morchella esculenta*, like the truffle, belongs to the sub-order *Ascomycetes*. This fungus has a stalk from one to three inches long; a spherical hollow cap, the size of an egg, of a pale brown or even grey colour, and deep pitted over its whole surface. It grows in orchards and woods, springing up in early spring and summer, and is generally believed to abound in woods where fires have been made. The country people in Germany were so persuaded of this, that they made a practice, until the custom was put down by law, of firing the woods in order to obtain a crop of Morels. The plant has a slight smell and an agreeable taste; it is employed for various purposes in cookery, both fresh and dried.

When the vast numbers and universal dissemination of Fungales are taken into consideration, together with their diversity of form and size, it is not surprising that botanists have been much puzzled over them. Fries discovered no fewer than two thousand species within the compass of a square furlong in Sweden. Of the *Agarics* alone above a thousand species are described. In size they range from the minute *moulds* which are found to produce death in the silkworm and the common house-fly (which M. Deslongchamps found in the air-cells of the Eider duck, while alive, and which Professor Owen found in the lungs of a flamingo) up to the Great Puff-ball, which attains the diameter of a foot in a single night.

The different structures of Fungales have been equally puzzling. Some writers have questioned the propriety of classing them as plants at all; and it has been proposed to establish them as an independent kingdom, equally distinct from plants and animals. Others have adopted the unphilosophical notion that they are mere fortuitous developments of vegetable matter, called into action by special conditions of light, heat, and air. But the fact that the cultivated species can be propagated with certainty, is no doubt applicable to the whole. It is argued with more reason that many of the Fungales which have been ascribed to equivocal generation, are the effects of diseased cuticle, or of the underlying tissues on which the sporules have settled. Fries thus argues against these notions. "The sporules," he says, "are infinite, for in a single individual of *Reticulariæ maxima* I have reckoned 10,000,000, so subtle as to resemble thin smoke, as light as if raised by evaporation and dispersed in so many ways—by the sun's attraction, by insects, by adhesion and elasticity—that it is difficult to conceive the spots from which they could be excluded."

The Caries or Fungales which attack the wheat-plant and others of the Graminaceæ are, according to Queckett, *Mucedines*, to which he proposes giving the name of *Ergotætia abortans*. It belongs to the Concomycetes of Fries. This author considered it a diseased state of the plant itself, and placed it in his doubtful genus *Spermoedia*. From the investigations of Queckett it appears that the great mass of the *Ergot*, as it has been called, consists of the

albumen of the grain in a diseased state. Contrary to all former experiments, after the outside was scraped off, the interior under the microscope was found to be filled with globules of fatty oil; and the cause was evident. Outside of the ergotised grain were found a number of small oval or elliptical bodies about the six-hundredth part of an inch in diameter, containing smaller granules, which were found to be sporidia of a fungoïd plant, attached to filaments which developed themselves early in the growth of the grain, producing this diseased state. It grows in the interior of the ovary of the cultivated wheat (Fig. 320), and of some others of the Graminaceæ. At the maturity of the plant which it has invaded, the diseased grain is nearly of the size and form of the healthy grain (Fig. 321), differing chiefly in its brownish colour, and unequal division. The fungus would seem to have its birth in some manner in the flower of the wheat-plants; the wasting influence is drawn from the stigmata and stamens of the parent plant. "Having," says M. Tulasne, "subjected the pulverulent matter which filled the ovary to the microscope, and especially the parts adjacent to the periphery, which seemed to ripen more slowly, we recognised that spores attached themselves to it in great numbers by short peduncles, to a sort of trunk, or common, thin, colourless branches of a fragile nature, which seem to be re-absorbed, or at least to disappear, as the spores they engender approach maturity. The tissue constituted by them is then added to the ovary. This process proceeds until the whole ovary is crammed with seeds of the vegetable parasite. When this seed germinates," says M. Tulasne, in continuation, "its reticulated tegument is broken at some point of its surface, but without

Fig. 320. Canes on Wheat.

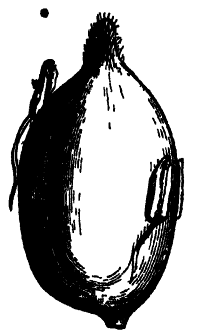


Fig. 321.—Diseased Grain of Wheat.

regularity (Fig. 322, 1, 2), and a thick and flexible tube issues from the opening, which continues to grow till it attains the length of about fifteen times the diameter of the spore. The shorter grains are usually crowned with a sheaf and a bundle of secondary spores designated *sporidia* (Figs. 323 and 324). These

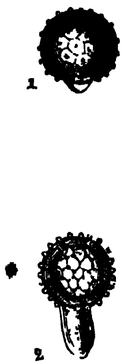


Fig. 322. Spores of Caries.

Fig. 323.—Spores germinating.

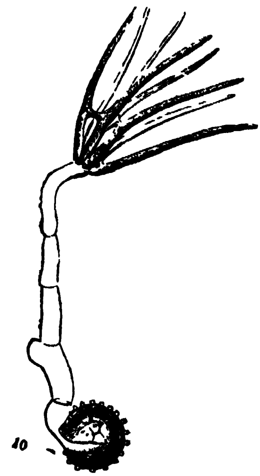


Fig. 324.—Sporidia.

are very slender linear bodies united into pairs in their lower part by a short and rigid band, which gives to the pair the form of the letter H. This bouquet of spores being matured, the germs soon destroy themselves. The reproductive pairs are then isolated from each other, spreading abroad, without altogether dissociating themselves, on the surface of the subjacent body. Some germinate quickly, and emit, especially towards their summit, very fine filaments, which quickly spread themselves (Figs. 325 and 326). Others, and those in much greater numbers, give birth to secondary sporidia, thickish oblong or arched bodies, which appear to be the most important agents in the multiplication of Fungales. These will be secondary sporidia, which germinate while emitting one or many very fine filaments at certain points of their surface."

THE SMUTS.—Blights or uredines are another family of parasitic fungales belonging to the sub-order of Concomycetes. They occur

on the diseased tissues of plants. The spores are single, often partitioned on more or less distinct spherospores, the flocci of the fruit obsolete, or mere peduncles. The Smut, properly so-called, *Ustilago segetum*, particularly attacks oats and barley. It develops itself in the parenchyma of the floral envelope, in the axes of the spikelet, and in the peduncles of the Graminæ. When the

Fig. 325. Bundles of Spores. Fig. 326.

wind has dispersed the spores of the parasite, the plant only remains a blackened skeleton, and scarcely recognisable. The presence of the fungale draws after it the abortion more or less complete of the organs of the flower which it has attacked, the sterility of the spike, and a notable alteration of their normal structure.

Another species, *Ustilago Maydis*, with black spores, is equally disastrous to the cultivators of Maize or Indian corn. Fig. 327 represents a spike of maize with white grains. Fig. 328 presents the vertical section of an ovary surrounded with bracts, tumified by the pressure of the fungus. The black spots indicate the formation at these points of the black powder of *Ustilago Maydis*. This fungus attacks alike stem and spikelet, producing upon it excrescences more or less voluminous and deformed. "In dissecting the ordinary excrescences while they are still gorged with juices," says M. Tulasne, "we find them to be formed of a parenchyma of great cells, frequently with gaps, and traversed by a small number of fibro-vascular bundles; it is a structure analagous to that presented by the bracts and ovary invested by entophytrio. The chasms in this parenchyma, and frequently even the interior of its constituting cells, are filled in some cases, when they are examined before the final pulverescence of the Ustilago

takes place, with the matter of the fungus. It is a mucous, gelatinous, and perfectly colourless substance, which separates little

Fig. 327.—Fireblast, or Smut, on the Maize plant.

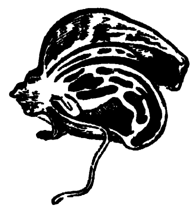


Fig. 328.—Section of a Maize Ovary attacked by Smut.

by little into small polyhedral rounded masses, which by re-clothing themselves, sometimes according to a tegumentary system, become spores."

The Vine Fungus, which is the *Oidium Tuckeri* of Berkeley, is supposed also to be a state of Erysiphes—a genera of small fungi which the world has a great interest in being acquainted with. The elegant structure and varied form of some of these minute fungi had fixed the attention of mycologists upon them, long before the unforeseen result of M. Tulasne's investigations became known. These microscopic plants possess, according to M. Tulasne, no less than three kinds of reproductive apparatus, which make their appearance successively, and the fungus destructive to the

vine is only another species of Erysiphes, which forms the two first evolutions only of the reproductive organs.

The organs of vegetation in the Erysiphes consist of a *mycelium* formed of fine thread-like filaments, furnished with spores the form and functions of which remind us in many respects of the suckers of the Dodder-plant; which leads to the inference that in these fungi we see parasites which live upon the green or living parts of vegetables, particularly upon the leaves. Certain filaments of the mycelium bear straight branches more or less numerous, which swell at the extremities into ellipsoidal utricles, and constitute small organs, often in the form of a chaplet of beads, formed

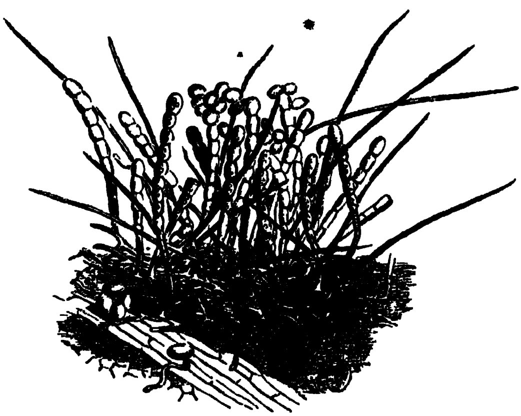


Fig. 329.—Reproductive Organs of Eresyphus (Conidia).

of reproductive cells, analogous to the fugitive buds of cotyledonous plants. To this first reproductive system M. Tulasne gives the name of *Conidies* (Fig. 329).

Another class of organs consists of spherical or ovoid vesicles, generally pedicellate, and filled with innumerable small oval or oblong corpuscles. This second system, represented in Fig. 330, he calls Pycnides.

Such are the two sorts of reproductive organs which constitute the *Oidium Tuckeri* of Berkeley; which is, however, only one of the *Erysiphes*, the last and perfect form of which has not yet developed itself.

This, the latest and most important form, consists in globulous conceptacles, sessile, at first colourless, then yellowish brown, and finally black and more or less spotted, which bear, like the

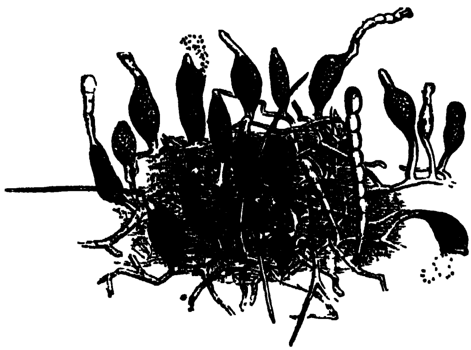


Fig. 330.—Reproductive Organs of Erisyphus (Pycnides).

two first sets of organs, certain filaments of the mycelium. They are all accompanied at maturity with a variable number of filiform appendages, whose form, dimensions, and position vary with the

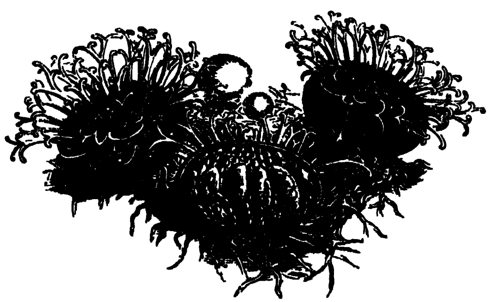


Fig. 331.—Third kind of Reproductive Organ of Erisyphus (Conceptacles).

spores under consideration (Fig. 331). They are simple or branching, and frequently terminate in arms divided into pairs. In the bosom of the conceptacles are found sacs or *theca*, variable also in number, generally ovoid, attached by a short claw to the base of the conceptacle. The number of spores, which are constant to each species, vary from two to eight. The conceptacles open irregularly in order to permit the *theca* or spores to issue.

The Moulds were long supposed to have a very simple organisation, because they had been imperfectly observed. Even in our days they are very imperfectly known. It is now known, however, that some of them are endowed with multiplied reproductive apparata. The *Mucors*, which are the commonest of the Moulds, grow on organic substances in a state of decomposition, forming large catonous tufts, with vesicles full of greenish spores on the summit of long slender pedicels (Fig. 332). It has only recently been ascertained that the genera which had been named respectively *Aspergillus* and *Eurotium* are only two different and successive modes of fructification; *Aspergillus* being the fructification of the young, *Eurotium* that of the adult state.

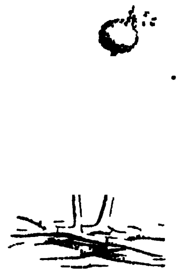


Fig 332.—Mosses.

The parasite which proved so destructive to the potato belongs to the family of fungi now under consideration; and here also we note two modes of fructification; one, namely, in which the spores are born naked at the extremity of the filaments, while in the other the spores are contained in certain voluminous vesicles. In a recent memoir, M. de Bary, professor in the University of Fribourg in the Brisgau, has directed attention to the very curious phenomena attending the germination of the naked spores, and it may be useful to present a *resumé* of these interesting researches.

The spores, or rather the so-called naked spores of the potato parasite, of the *Peronospera*, present us with three distinct modes of germination. In the first process germination is indicated by the emission of simple or ramified filaments, which possess the power of penetrating the tissues of the potato by piercing the walls of its superficial cells. The second form of germination is characterised by the formation of a secondary spore, from the summit of which issues a simple tube, which in due course attains the length of two or three times its greatest diameter, expanding like a vesicle at the extremity. When all the plastic contents of the spore are enclosed in this terminal vesicle, it is isolated from the *filamentous germ* by a partition, and thus constitutes a distinct cell. But this spore of the second order is a phenomenon of rare occurrence, and of secondary importance only, according to M. de Bary.

In the third mode of germination the spores (Fig. 333, A) divide themselves into a certain number of polyhedric portions (Fig. 333, B), which in a short time begin to issue, one after the

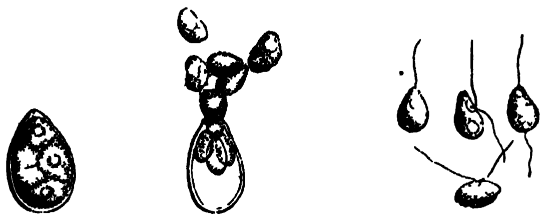


Fig. 333.—Germination of the Spores in the Potato.

other, by a round opening (C), thus constituting egg-shape zoospores furnished with two unequal cilia; the shorter of those most forward, in advance of the corpuscle, and the other dragging after it (Fig. 333, D). The movement of these small bodies lasts for about half an hour, describing a circle, which gets slower and slower until it enters a state of perfect repose. Now that it has become immovable, the zoospore takes a regularly rounded form, giving birth on one side to a germ-tube, slender and curved, which lengthens itself rapidly in water.

If the zoospores are sown upon the nurse plant, and other circumstances are favourable, the zoospores attach themselves to the epidermis of its fragments, giving out their usual germ, which after climbing a short time on the outside begins to enter the epidermic cells. Their extremities thus attached soon acquire a considerable thickness, which afterwards increases in a tabular form, which perfectly resembles the filaments of the adult mycelium in the *Peronospera*, and it soon insinuates itself into the depth of the tissues of the hospital plant.

The Lichens.

Lichens or Liverworts are cellular plants, requiring free access to light and air, and of simplest structure. They form irregular patches, more or less dry, according to their exposure upon the surface of stones, trees, and other bodies which they cover, while

decorating them with a thousand varied hues of colour. These Thallogens live in the air, never in water. Their existence may endure for hundreds of years; their growth and propagation are both excessively slow. They are found in all regions of the globe, from the tropics up to the poles. They grow on the summit of the loftiest mountains, in the plains and valleys, and at all intermediate heights. Near the limits of eternal snow, where all other signs of vegetation have disappeared, on the edge of glaciers, and up to the 70th degree of north latitude, that is to say, at the nearest point to the Pole which has been approached by man, the Lichens still vegetate. Humboldt and Boussingault found them growing near the summit of Chimborazo, and they are the last vegetables which are found on the slopes of Mont Blanc.

In form these universally disseminated plants are cellular and flowerless, formed of a lobed and foliaceous substance called a thallus, which is formed of a cortical, and medullary layer—the former being cellular, the latter both cellular and filamentous. Others are crustaceous, when the cortical is coloured and the medullary layer is colourless. The reproductive matter is of two kinds:—1. Spores, naked, or lying in membranous amylaceous tubes or thecæ immersed in nuclei of the medullary substance, which burst through the cortical layer and colour, and harden by exposure to the air in the form of little discs, called shields. 2. The separated cellules of the medullary layer of the thallus. These, called gonidia, are of a green colour, and lie singly or in clusters beneath the cortical layer of the thallus, and break out in clusters called soridia, or in cups called cyphelia.

Although Lichens, with one or two exceptions, are never immersed in water, they are said in all cases to be developed in humidity, resembling in that state Phyceæ and Confervæ; but as soon as the humidity diminishes, the under part dies, and an inert leprous crust is formed, which becomes the basis of the plant. Hence the two sorts of tissues—living cellules forming the vegetating part, and dead cellules which have lost their cohesion; the latter have their reproductive powers while every part of the living stratum has been ascertained to possess reproductive properties.

Some Lichens are employed in medicine, others are subjects of

domestic economy, some in the art of painting. The Iceland Lichen (*Cetraria Islandica*), Fig. 334, is demulcent, and is em-

Fig. 334.—Cetraria Islandica.

ployed in many affections of the chest; the great quantity of fecula which it contains renders it esculent. *Sticta pulmonaria*

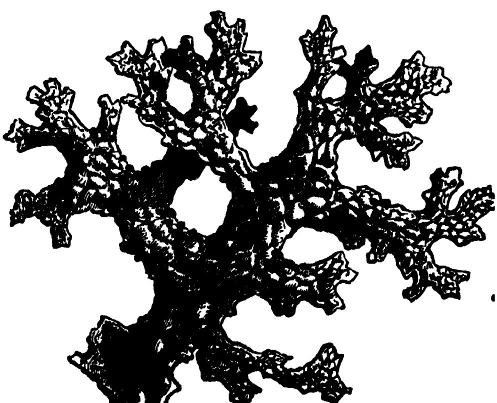


Fig. 335.—Sticta Pulmonaria.

(the Lung-wort lichen), Fig. 335, is in Siberia a substitute for the hop in the preparation of beer. *Cladonia rangiferina* is an excellent substitute for pasture to the reindeer, whose instinct readily discovers it even under the snow.

The Orchil or Archil is a valuable die, and *Lecidea Tartarea* is the cudbear of commerce, which is imported to the value of £80,000 annually.

One of the most curious of this family of Thallogens is *Lecanora esculenta,* a lichen which is frequently met with in the mountains of the arid deserts of Tartary. It is found in great abundance in the Kirguis deserts to the south of the river Jaïk. It seems to fall from the sky as a sort of miraculous manna. Men and beasts are nourished on it. But what is really remarkable is that it occurs in the form of small globules, whose size may vary from the head of a pin to a hazel-nut. They are invariably free, being attached to no other body. It follows from all this that the Lichen develops itself rapidly; has vegetated and increased while the wind transported it from one place to another. The light mass which constitutes these Lichens are, in short, often transported by the air to great distances. The manna which supported the Israelites in the wilderness is supposed to have been a species of comestible Lichen of rapid growth, which the wind carried and spread out at their feet. These falls of the so-called manna are by no means rare in our days. In proof of this, one of the secretaries of the Turkish embassy, Fahri-Bey, wrote to me on the 22nd August, 1864, as follows:—"Last year, in the neighbourhood of Kutahia, in Asia Minor, after a great storm, accompanied with a beating rain, the grains enclosed fell from the sky in great quantities. As a great dearth had prevailed there for some time, the inhabitants eagerly profited by the occasion, and made it into bread. In stating this fact for your information, I would pray of you to analyse them, and favour me with your opinion upon them." The grains enclosed in the letter were the grains of the comestible Lichen, the *Lecanora esculenta* now under consideration.

What then is the internal organisation of Lichens?

These Thallogens, when perfect, consist of a nutritious or vegetative apparatus designated the *thallus*, and of double reproductive organs.

A thallus, which is sometimes imperceptible, may nevertheless attain the length of ten yards. The colours which it commonly presents are white, grey, yellow, citron, orange, green, brown, or black. As to its form, it is *foliaceous* in *Parmelia; fruticulose,*

in the *Usneas; crustaceous,* as in the *Squamaria; hypophleod,* or hidden under the epidermis of the trees, or under the woody fibres, as in the *Verrucaria, Xylographa,* &c.

In order to give some idea of the anatomical structure of the thallus, it will suffice to mention *Parmelia parietina,* the thallus of which does not exceed the three-hundredth part of an inch in thickness.

Thin as it is, however, this organ presents four very distinct regions. Its upper part consists of a bed of thick closely consolidated cells, of a yellowish colour at their surface only. In front of the lower part of the thallus is another cellular bed, white, like the first. Between these two epiderms are confined, 1st, the green seeds known as *gonidia,* and formed of a bed called *gonidial;* 2nd, a kind of *medulla,* or pith, formed of filamentous elements loosely interlaced or knitted, which is the medullary bed, and which encloses the air in the mesh.

If we pass from the vegetative to the reproductive system, we find that it consists of the fructifying or female organs, and a fecundating or male apparatus; the first being represented by the *Apothecceia*—namely, the cups or shields containing the fructification; the second by the *Spermogonia.*

The *apothecceia* of fruits of the Lichens develop themselves on the upper face of the thallus, or upon that part of it which is turned towards the light. They strongly resemble the small disk or nucleus—black, brown, yellow, rose-coloured, red, and sometimes interspersed with brown or grey. In size they are extremely variable; the smallest are under the one-twentieth of an inch, whilst the largest may be an inch.

The *spermogonia* are generally very small organs, rounded or oblong, lodged sometimes in particular tubercles, but more frequently immerged in the superficial beds of the thallus.

Many reasons lead to the conclusion that the *spermogonia* are the male organs of the Lichens. At first they present themselves parallel in the fruit, or simultaneously with it in the same individual, and at other times only upon sterile individuals in such a manner that in the latter case the *apothecceia* and the *spermogonia* develop themselves upon different individuals. The tenuity of the corpuscles contained in the *spermogonia,* their immense numbers

relatively to the number of their spores, their solidity, their form, their equality as to size, the absence of all germinating faculty, are so many circumstances which seem to identify them with the attribute of being agents of fecundation analogous to the anthero-zoïds of other Thallogens. But they possess, so far as is known, no organs of locomotion.

Class II.—Acrogens.

So-called from their stems growing in height and not in diameter. They are flowerless plants, like Thallogens, the stems and leaves of which are distinguishable, and in other respects they approach closely to higher structural forms, even acquiring the stature of lofty trees in some of the orders. They have breathing pores, or stamatæ, on their surface; their leaves and stems are distinctly separated in most of the species; in some of them the spiral spermatoids, which form an important portion of the internal anatomy of the higher forms of vegetation, are found well developed, and they are propagated by reproductive spores, but without any direct evidence that Acrogens possess organs requiring to be fertilised, the one by the other, in order to be reproductive. The Acrogens correspond with the Acotyledons of De Jussieu, and the Cellulares of De Candolle.

4. Muscals.	Cellular, sometimes vascular. Spore cases plunged in the substance of the frond, or enclosed in a hood which serves as an involucre to the seed vessels.	XV. Ricciaceæ, crystal worts. XVI. Marchantiaceæ, or liverworts. XVII. Jungermaniaceæ, scale mosses. XVIII. Equisetaceæ, or horsetails. XIX. Andræceæ, or split mosses. XX. Bryaceæ, or urn mosses.
5. Lycopodals.	Vascular, with axillary or radical spore-cases, one or many-celled, spores of two sorts.	XXI. Lycopodiaceæ, or club mosses. XXII. Marsilleaceæ, or pepper worts.
6. Filicals.	Vascular with marginal or dorsal spore-cases, one-celled, usually surrounded by an elastic ring spore of one sort.	XXIII. Oppioglassaceæ, or adders' tongues. XXIV. Polypodiaceæ, or ferns. XXV. Danæaceæ, or Danæads.

Of the Muscals, Hepaticals or Liverworts have a loose cellular texture, usually prostrate, and producing rootlets in their sides: they grow in damp places. Sometimes the stem and leaves unite and form a confluent expansion; in other cases the leaves are distinct from the stem. "The most remarkable points of structure in Hepaticeæ," says Dr. Lindley, "is the spiral filament, as it is called, lying among the sporules, within the theca or sporule case, and having a strong elastic

force. This consists of a single fibre, or two twisted spirally in different directions so as to cross each other, and is contained within a very delicate transparent perishable tube." This order contains the—I. *Marchantiaceæ*, or Liverworts, which root on the ground, on walls, rocks, and damp places; II. *Ricciaceæ*, floating plants, rooting on the ground, their fructification immersed in the frond. III. *Anthoceratеæ*, annuals with fleshy or membranous fronds, spore cases raised on a pedicel, two or three inches long, with a free central columella. IV. *Jungermaniaceæ*, frondose or foliaceous plants, spore cases opening with four valves, spores mixed with elaters.

The structure of the plants, some of them of microscopic minuteness, is singularly interesting. They are furnished with leaves, arranged over a distinct axis of growth; and their reproductive organs are of two kinds, the most general being the urn sporangium or theca, in which the spores or seeds are generated. If examined in the season of growth, it will be observed that some of the axils of the leaves contain clusters of articulated filaments, swollen at the base, some of them being larger than the others. After a while this body is found to have an exterior membranous coating, which separates from the base in a cup-like form; this is the young urn, which gradually acquires a stalk called the *seta*, upon which it is raised above the leaves carrying the other membrane upward on its point, covered, when full grown, with a cap, called its *calyptra*. The urn is closed by a lid, its *operculum*, and contains the spores in a cavity surrounding central column, or *columella*. Its rim is bordered by a double set of teeth, like jointed processes, called the *peristoma*.

A second set of organs called *Antheridia* are observed, which also form clusters in the axils of the leaves; they are membranous cylindrical jointed, or jointless, bodies, irregularly opening out at the point and discharging a mucous turbid fluid. Now the function of these two sets of organs has long been a subject of dispute. The discovery of the two kinds of organs, the *Antheridia* and *Pistillidia*, in the Mosses and Hepaticeæ, and the analogous spiral filaments in the *Characeæ* were supposed to indicate a sexual organisation. Professor von Mohl pointed out the analogy between the development of the spores of the Cryptogamia or Thallogens and

the pollen-grains of the flowering plants, but considerable obscurity still surrounds the question. Mr. Valentine traced an evident analogy to ovules in cells closely resembling the parent cells of pollen and spores. While Schleiden thought he observed fertilisation of the supposed ovules by the smaller spores. The view now entertained by the best authorities as to the reproduction of the mosses is that the Antheridia are male organs which by means of the spiral filaments exert a fertilising influence upon the Pistillidia. But no such fertilising process has actually been observed in the mosses, the evidence being only circumstantial.

The Mosses.

The Mosses, which now number not less than ten thousand species, are humble plants, but they have no insignificant part to play either in the economy of Nature or in the physiognomy of the landscape. Trees, walls, rocks, and ruins assume a smiling or picturesque aspect under their mossy covering in its varied colours. The *Phascum*, growing in the gravelled alleys of woods and gardens, are so very minute that in some cases they scarcely attain the height of the hundredth part of an inch. The *Hypnum*, which often clothe the banks of brooks in shady places, or form small islets at the foot of willows and poplars, or attached to the trunks of these trees, are vigorous vegetable organisms which do not readily perish. The *Fontinalis* are small grass-like mosses which float in the middle of running brooks. The *Sphagnums* grow in marshy places, where they perform an important part in the formation of bog turf. These aquatic mosses grow very rapidly, extending their roots in such a manner as to occupy by degrees the whole interior of the pool which they occupy. Their thin and delicate tissues absorb more than sixteen times their weight in water; and when they die they accumulate in the bottom of the water, and form with mud and the detritus of other plants a mixture which, when consolidated by time, is cut out in oblong squares, and under the name of peat-turf forms an important article of domestic fuel in some countries.

The *Polytrichum*, commonly called the golden moss, is one of the most elegant of its kind; it is larger than the common Mosses,

and grows generally among heaths, in fir woods and bogs. Its principal stem creeps along the ground, throwing out from time to time adventitious roots, which penetrate the soil, throwing out branches to the surface. These branches carry the leaves, are narrow, lanceolate, or awl-shaped, and finely dentate or serrated on their edge; imbricate in a spiral form round the stem; the leaves of the lower part assume a reddish colour at maturity.

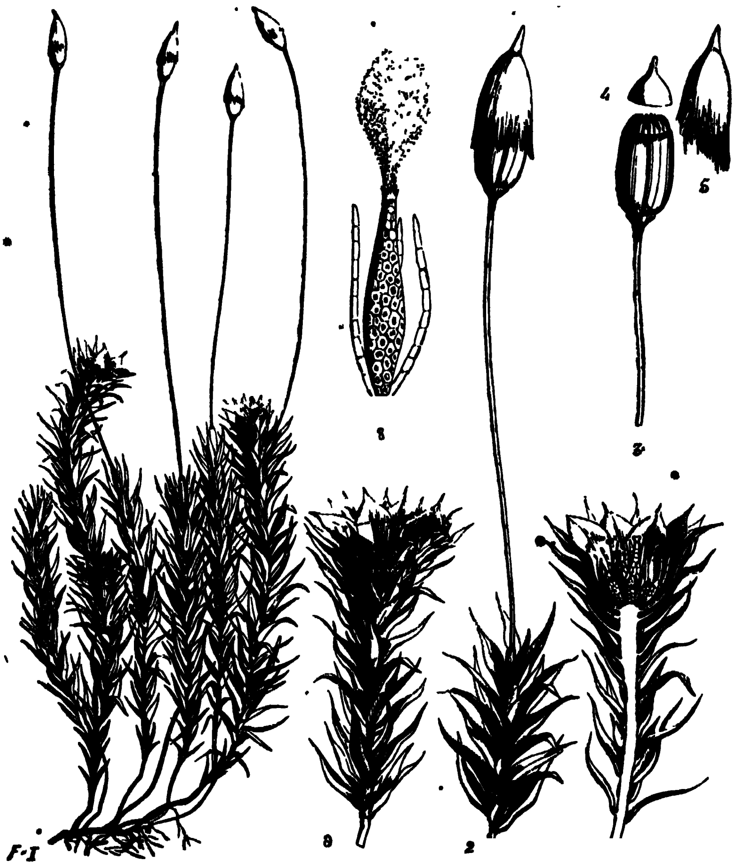


Fig. 336.—Polytrichum.

In Fig. 336 the stems terminate, as we see in Nos. 1 and 2, by a long reddish filament carrying a pointed or cone-shaped cap composed of silky hairs, disposed longitudinally, and of a bright

yellow colour. If this cap is raised (see No. 6) we see that it is the cover of an urn-shaped vessel, which contains a prismatic body (No. 9) furnished with a species of covering (No. 8), seated upon a small ledge which is circumscribed by a very thin ridge of greyish colour. Held horizontally, the ledge is composed of small pointed teeth curving towards the interior, and connected by a horizontal skin. There are sixty-four of these teeth. As to the interior of the prismatic body, it is hollow, and encloses a multitude of small greenish granules, perfectly free, and which make their escape with great facility when the urn bursts.

There is every reason to believe that these granules reproduce the species by germination. There are certain other seeds, but their organisation is so simple, and show so little resemblance to the seeds of the higher orders of plants, that they are called *spores*. These are enclosed in the interior of a membranous sac, which covers the walls of the prismatic body, and adheres to a central axis called the *columella*. This prismatic body, in fact, is the *urn* of the mosses. The free edge of the urn crowned by the teeth is the *peristomium;* here the peristome has sixty-four teeth. The covering reposing on the peristome bears the name of operculum. The cap of yellow hair which shelters the urn almost entirely is the *calyptra*. Finally, the filament which contains the stem and supports the urn is the *theca*. Of this nomenclature, Dr. Lindley in the Outlines of Botany remarks, that to the uninitiated it requires explanation, otherwise it might be supposed to apply to some vegeto-animal. "The calyptra," he says, "may be understood to be a convolute leaf; the operculum another; the peristomium one or more whorls of minute flat leaves; and the theca itself, the excavated distended apex of the stalk, the cellular substance of which separates in the form of sporules."

This urn, then, results from the development of a small apparatus bearing a strong resemblance to a long-necked bottle, which is traversed very perceptibly in its entire length by an open canal, expanding at the summit in such a manner as to present some analogy with the pistil of plants of higher organisation, and which has been called an *archegonium*. At first many archegones are enclosed in the terminal rosette of the stem (as in 3 and 7, Fig. 336), but only one of these is ultimately developed into the urn borne at the summit of the theca.

The appearance of these archegones is contemporaneous with that of the fertilising apparatus which makes its appearance in the centre of the terminal rosette of the different urn-bearing stems. The Polytrichum are then *diœceous*. These supposed fertilising organs consist of small greyish elongated bodies (as represented in 4, Fig. 391). They are more or less spindle-shaped, and they are accompanied by cylindrical fillets, called *paraphyses*, or cellulose sacs, which open from above, leaving their contents to escape by abrupt jerks at given moments until the organ is completely emptied.

When the matter thus ejected is carefully examined, it is found to consist of a tissue very distinctly resembling rings of mail, in which each cell encloses a small body rolled up into a ball, with a very perceptible swelling upon one point of its circumference. These little bodies are in a continual state of rotatory motion; the tissue which contains them dissolves quickly on contact with water. The little sac, which is called the *antheridium*, becomes flat and dry after the emission of the movable corpuscles which it contains. These are *antherozoïds*.

We have said that the appearance of the archegonium is contemporaneous with the antherids. Whatever difficulties may appear to oppose themselves to the idea that these antherozoïds become archegones, it is impossible to deny that such transposition takes place, for on the archegones of certain mosses living antherozoïds have been found which had already traversed one-third of the length of the neck.

It follows, therefore, from the structure of the archegonium and antherids, and from the curious observations which have been recorded, that there is now little doubt of the sexuality of these little plants. This is further confirmed by the fact on which Hedwig founds his principal argument, namely, that in the diœceous mosses the archegones arrive at maturity when individuals furnished with antherids grow in the same neighbourhood.

Filices, or Ferns.

In their most graceful type—the Tree Ferns—this order of Acrogens rivals the most beautiful Palms. When they have

attained a height of forty or fifty feet their stems form a noble column, some five or six inches thick, from the summit of which flows a panicle of pinnate leaves intersected by a thousand incisions, the terminal tuft which crowns the summit of the trunk curving at all times into a sort of cross, whose graceful curve adds greatly to the elegance of the tree. Their chief anatomical peculiarities are as follows:—

The leaves are termed *fronds*, and they bear the organs of fructification in little cups or receptacles on the edges, or on the under surface, in the form of little masses of granules, termed *sori*, consisting of a containing organ termed *sporangia*, *thecæ*, or *capsules*, surrounded by a ring termed *gyrus*, or *annulus*, and a number of contained cells termed *spores*, or *sporules*, from which the new plant is produced. The foot-stalk of the leaf or frond is called a *stipe*, and consists of bundles of bare woody fibre and scalariform vessels, connected together by cellular tissue, which pass down into the stem under the bark, forming the zones of the wood. In the Tree Fern the rind or bark consists of one or two layers of

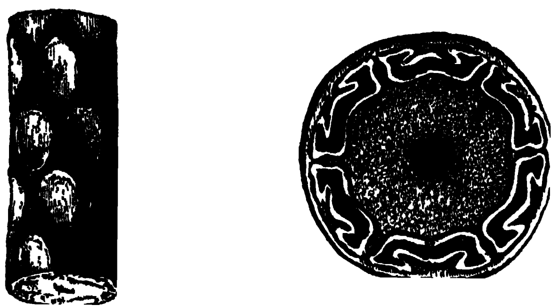


Fig. 337.—Stem and section of a Tree Fern.

cellular tissue, and is marked from top to bottom by the cicatrices left by the fallen leaves (Fig. 337, *a*). These cicatrices occur irregularly and at considerable distances apart near the foot of the tree, but at regular distances and almost close together towards the summit of the stem, showing that its leaves are produced at the top and in successive clusters, and that the trunk has increased in height after the fall of the leaf. Again, a large portion of the transverse section of the trunk is seen to consist of cellular tissue;

Plate II.—The Arborescent Fern of Brazil.

and through this the wood passes, the centre being occupied by a mass of scalariform duct, so called from the resemblance which its perpendicular sides and transverse lines bear to the sides and rounds of a ladder. This form of tissue is interrupted by large spiral vessels; the wood is also arranged in circles, or bundles, with a wavy outline, but only near to the bark. These circles seem to be sent down from the fronds, and as the fronds surround the stem, the bundles sent down from them lie side by side until they form a circle. There is a peculiarity in the growth of the Tree Fern, that the interval between the cicatrices enlarges as the tree increases, showing that the stem of the tree increases in height not only at the apex for the time being, but afterwards in the body of the trunk.

The mode of germination in the Ferns seems to be this:—The sporule, after extrusion from the sporangia, bursts its envelope and emits a leafy expansion from its centre, which subsequently forms a bud and then a plant. Plate II. represents the Arborescent Fern of the Brazilian forests.

Fig. 338.—Trichomanes brebisetum.

In our climate these Acrogens are far from presenting the dimensions which they attain in the tropics. Our Ferns are only perennials, with a short rhizome or spreading roots, whose leaves rarely exceed four or five inches. Even in the tropics and in the southern hemisphere the *Hymenophyllæum* and *Trichomanes* (Fig. 338), which grow only in humid places, at the foot of old trees, or upon rocks bathed in running brooks, are generally of small size. The delicate leaves are desti-

titte of epidermis, and consist of a simple blade of cellular tissue

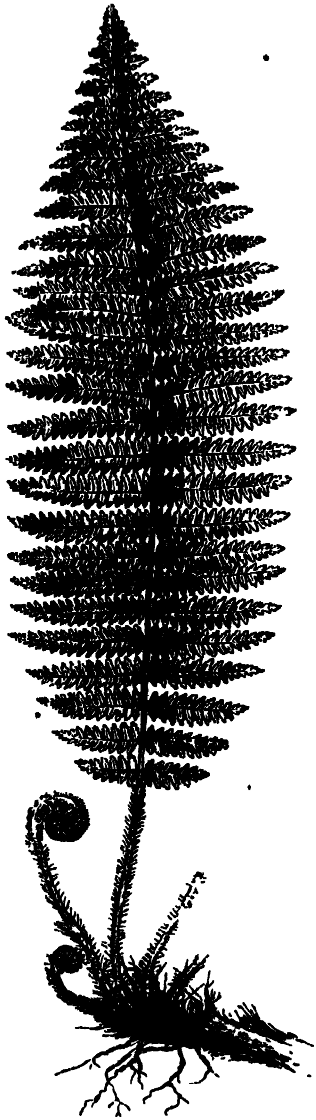


Fig. 339.—Male Fern.

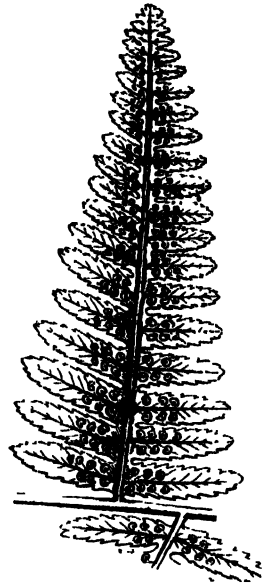


Fig 340.—Lower surface of the Frond.

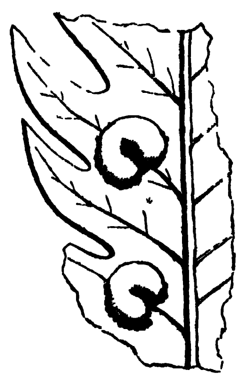


Fig. 341.—Magnified portion of the lower surface.

traversed by nervures formed themselves of scalariform vessels.

In order to study more closely the structure of a fern, let us examine the *Nephrodium filix-mas.*, commonly known as the male fern (Fig. 339).

This plant is common in the woods and sterile places. It carries upon its subterranean stem, which creeps along horizontally, certain reddish scales. The leaves are large, petiolate, and much intersected. On the under surface of the leaves, or of what has the appearance of leaves, and which, as already stated, are called in the language of botany, *fronds*, we find little rounded, or, rather, kidney-shaped projections. Each of these projections are formed by groups of small bodies, yellowish green at an early age, brown

Fig. 342.—Sporangia of the Male Fern.

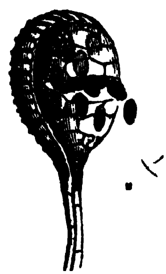


Fig. 343.—Dehiscence of the Sporangia.

at their maturity, and which are covered by a thin greyish pellicle. Each group of these little bodies or sporanges bears the name of *sori;* the pellicle which covers them is called the *indusium*. Fig. 341 is a greatly magnified representation of the organs which occur on the lower surface of the fronds of the male fern.

The sporanges or *capsules* (Fig. 342) are pedicellate cellulose sacs, furnished on their circumference with an almost entire circle of cellules, larger and thicker than the other parts of the wall. These cellules form a sort of ring, which by growth, or by certain hygrometric changes, seem to determine the irregular rupture of the walls of the capsule (Fig. 343), and by these movements pour out a number of egg-like irregular globules, which were long considered to be the seeds of the plant, and were called *spores.* But this assimilation is ascertained to be absolutely

opposed to the facts. In the diverse genera which constitute the great family of Ferns, the apparatus under consideration has very different functions.

In the *Polypodaceæ* the rounded sori are destitute of indusium. In *Pteris* it extends along the edge of the frond, and opening from the inner side, protects the sori. In *Scolopendrium*, the sori, approaching by pairs, are protected by an indusium, which is to all appearance bivalve, and disposed in oblique lines. In *Osmunda* the capsules form terminal clusters upon the nervures of the upper parts of the frond, contracted and modified, and often destitute of the ring as an indusium.

The reproduction of ferns has been closely studied in our days by Herr Nægeli, a distinguished German phytologist, and still more recently by Herr Leszcyc-Suminski. We shall follow the curious observations of botanists in their revelations of the strange mode of reproduction among the ferns, remarking, however, that the investigations of Mr. Henfrey and other observers, English and foreign, of high reputation, while confirming many of Herr Suminski's observations, draw other inferences from them, M. Thuret, a highly judicious guide, preferring to suppose that the true fructification of these plants still remains to be discovered.

It had long been known that the so-called spores of ferns were susceptible, in favourable conditions, of germinating and reproducing the original plant, and this is the generally received idea of its development: the capsules or sporanges are considered to be the female organs; and the male organs are supposed to be found in the hair-like glandular filaments found in their vicinity. Some new and remarkable observations, however, have shown that the phenomenon was not so simple as it was thought. The structure of the body which was supposed to be the male organs did not correspond with the antherids of other cryptogams. Neither had the presence of antherozoïds confirmed the terms assigned to them. In short, nature has neither placed the antherids of the ferns in the middle of the sorus, nor upon the pedicels of the capsules. Contrary to the provisions demanded by theory, it is upon plants in procees of germination that we find these organs; upon individuals which have only been in existence

for a few weeks, and which still consist of only a small number of cells. For this most important discovery we are indebted, in the first place, to Herr Nægeli, and it was confirmed some year later by the observations of Herr Leszcyc-Suminski.

If we follow the germination of a fern-spore with Herr Suminski, we find that its external membrane, resistant and coloured, is broken, and by the opening thus formed in the external membrane issues, in the form of a sort of tube, certain cellules reproducing and multiplying themselves at the extremity of the tube. From this results sometimes a foliaceous expansion, heart-shaped, in the form of a pear (Fig. 344, *a*), whose dimensions in *Pteris serulata* may be an eighth of an inch by a tenth. In the upper part of this small organ or *prothallium* would appear in due course the root or radicle, then the *antherid*, and finally the archegonium would appear.

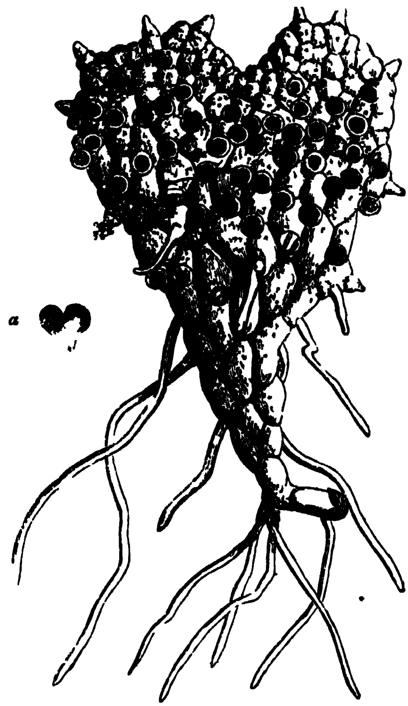


Fig. 344

The *antherids* are small cellular mamelons, formed, according to M. Thuret, of three cellules superimposed on each other, as in Fig 345. In the young antherids (*a*), says this botanist, the central cavity, surrounded by the second ring-like cellule, is only filled with a greyish granulose matter; by degrees, small sperical bodies are seen, which are the *antherozoids*. As these develop themselves the central cavity increases in volume, and presses strongly upon the walls of the peripheric cellule. Finally the time comes when the pressure is so great that the antherid is suddenly burst; the uppermost

cellule, which had served as a covercle or lid to the central cavity, is broken, or is occasionally expelled through the fracture at the cuticle (Fig. 346), the *antherozoïds* being expelled at the same time.

At the moment of their expulsion the antherozoïds present themselves in the form of little greyish spherical vesicles, whose

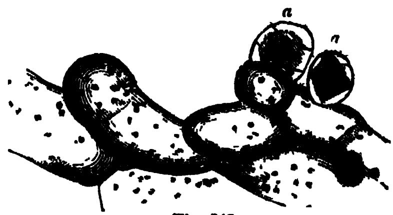


Fig. 345.

Fig. 346.

Fig. 347.

contents are very indistinct (Fig. 347). At first they are immovable; but after some minutes they begin to unroll themselves suddenly, and dart into the ambient liquid with inconceivable rapidity. They now turn themselves with gyratory movements, which are sometimes continued without interruption during one, and even two hours. If a drop of iodine is added under the microscope, these movements are suddenly arrested. Their body, twisted and contorted, forms a sort of spiral ribbon; it is besides imperfectly defined about the extremities. The locomotive organs of these strange bodies consist of bundles of short cils, in great

numbers, forming a sort of crest, which emanates from the anterior part of the body. The number of these cils is sufficient to account for the extreme rapidity with which these antherozoïds move.

These facts overturn all our notions as to the distinctions of animals and plants. Here are simple vegetable organs which seem to have the power of motion; and if we reflect that on the other hand there are animals, as the sponge, corals, and adult oysters, which are altogether immovable, we may well ask which is the plant and which the animal? We can only reply that the distinctions which science is compelled to draw among living beings become impossible when we reach the confines of what is usually designated the two kingdoms of nature.

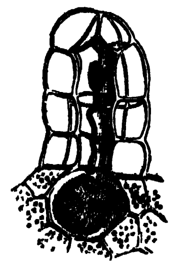


Fig. 348.
Isolated Archegonium.

The female organs of the plants which occupy our attention are less numerous than in the preceding orders; a *proembryo* does not bear more than from four to twenty (Figs. 346 and 348). They occupy the lower surface of the *prothallium*, but in front of the side of the hollow; each of them presents itself as a rounded cavity, plunging into the interior of the parenchyma, and communicating with the exterior by a sort of chimney, so to speak, formed by sixteen transparent cells disposed in fours, the one above the others (Fig. 348).

We ought to remark here, that the two kinds of organs which have been described may exist at once in the same prothallium as in Fig. 346, or they may be distributed upon several, as in Fig. 344. They are, then, monœceous or diœceous. As to the fact of the fecundation, it can no longer be contested. Herr Suminski has seen and figured the antherozoïds in the interior of the cavity of the *archegonium*, and his observations have been confirmed by other observers.

Without entering into details respecting the development of the embryo vesicle in the interior of the cavity of the archegone, we may remark that we only see a single plant issue from the *proembryo*, as if a single archegone had been fertilised, or at least one only takes such a form as to hinder the growth of all others.

To conclude, the capsules which develop themselves on the

lower surface of the fronds of ferns are not fruit, as has been assumed until lately; nor are the spores enclosed in the capsules seeds. The male and female reproductive organs are developed on a small and transitory cellular apparatus resulting from the germination of the spores.

Class III.—Rhizogens.

The Rihzogs are a most anomalous collection of spores, at once leafless and parasitical. They have the loose cellular organisation of Fungi, traces of a spiral structure among their tissues, with stem and root analogous to the thallus of Fungi, and probably partaking of their singular mode of growth; their flowers are like more perfect plants, and their sexual organs complete; their embryo, without visible radicle or cotyledons, presenting the appearance of a spherical or oblong homogeneous mass, adding to a fungal mode of growth a perfect sexual apparatus.

Rhizogens.	Ovules solitary, pendulous, one-seeded .	XXVI. Balanophoraceæ.
	Ovules parietal, many-seeded, calyx 3, 4, 6-parted, anthers opening by slits	XXVII. Cytinaceæ.
	Ovules parietal, many-seeded, calyx 5-parted, anthers opening by pores	XXVIII. Rafflesiaceæ.

They are a singular class of parasitical plants, which have cellular scales instead of leaves, but with true flowers. They agree with Exogens in having sexual organs, and with the Fungi in the presence of a mycelium, and in their parasitical habits, and in their fungus-like consistence. The *Balanophoraceæ* are leafless root parasites, with flowers, brown, red, white, or yellow, but never green, having underground stems, rhizomes, or tubers, from which spring erect simple peduncles. They are found on the roots of the vine, maple, and oak; abounding in the mountains of tropical countries of America. The *Cytinaceæ* are parasitical on the roots of the Cistus of the south of Europe, and on the succulent Euphorbias of the Cape of Good Hope. *Rafflesiaceæ* are stemless plants of the East Indies, the flowers of which spring immediately from the surfaces of the branches, and are immersed among the scales which represent leaves.

Class IV.—Endogens, or Monocotyledons.

Endogenous or Monocotyledonous plants are herbaceous, very rarely woody plants; *Ruscus aculeatus* being the only species with woody fibres indigenous to this country. Schleiden, in describing the peculiarities of Endogens, and the manner in which they differ from Exogens, says that all plants whose development proceeds from the interior to the exterior are either limited or unlimited in their growth. Woody fibre generally assumes two different physiological phases: 1, Of an extremely delicate tissue, capable of rapid development, in which new cells are continually generated and deposited in two different directions, as in Fig. 349; namely, next the circumference when the tissue is of a peculiar lengthened kind, with thick walls and liber; and next the centre in the form of annular, spiral, reticulate, or porous vessels; 2. Of woody cells, which form wood properly so-called. Up to a certain point the development of the vascular system is the same, but in Endogens the active skin and delicate cellular tissue suddenly change, the partitions of the cells become thicker, then the generating power ceases; and when fully enveloped they assume a peculiar form, cease to convey any kind of formative sap, and all further development of vascular bundles becomes impossible; and therefore the production of woody bundles is limited. In Exogens, on the contrary, this tissue retains its vital function during the whole life of the plant.

Fig. 349.—Growth of Endogens.

The general characteristics of Endogens are a fructification springing from a stem; wood youngest at the centre; cotyledous single leaves parallel, veined, permanent; wood of the stem always confused, and indistinct in its fibre.

Endogens consist of 1,420 genera and 13,684 species, whose germination is endorhizal, whose embryo has but one cotyledon,

whose leaves have parallel veins, and whose trunk is formed of bundles of spiral and dotted vesicles, guarded by woody tubes, whose bundles are arranged in a confused manner and reproduced in the centre of the trunk. Leaves and stem are here distinctly separated. Spiral vessels, breathing pores, and sexual organs free from complication. The palms may be considered as the typical form of Endogens; the grasses are Endogens with hollow stem. Dr. Lindley divides the class into—

SECTION 1.—FLOWERS GLUMACEOUS, WITH IMBRICATED, COLOURLESS, OR HERBACEOUS SCALES.

7. GLUMALS.	Having flowers composed of bracts, that is, imbricated, colourless, or herbaceous scales. In the two first orders the ovule is ascending, the pistil compound; in the other three the ovule is pendulous, the pistil simple. The first approach the Palms; and the last, the Rushes, passing naturally to the Bullrushes.	XXIX. Graminaceæ, or grasses XXX. Cyperaceæ, or sedges. XXXI. Desvauxiaceæ, or bristleworts. XXXII. Restiaceæ, the tropical marsh plants. XXXIII. Eriocaulaceæ, or pipeworts.

SECTION 2.—PETALOID FLOWERS, WITH TWO CALYX OR COROLLA, OR BOTH, NAKED.

8. ARALS.	Flowers naked, furnished with true calyx or corolla, or both, having the sexes on different flowers, with rudiments of the absent sexes present; embryo axile, albumen mealy or fleshy, some altogether without albumen. Here we have the simplest structure of flowering plants, gradually approaching the Palms in the Screw-pines.	XXXIV. Pistiaceæ, or duckweed XXXV. Typhaceæ, or bullrushes XXXVI. Araceæ, or arums. XXXVII. Pandanaceæ, or Screw-pines.
9. PALMALS.	Flowers perfect, having both calyx and corolla seated on a branched scaly spadix, with a minute embryo lodged below the surface of a horny or fleshy albumen. Some Palms are hermaphrodites.	XXXVIII. Palmaceæ, or palms.
10. HYDRALS.	Floating water plants, with flowers perfect or imperfect, usually scattered, not arranged on a spadix. Embryo axile, without albumen.	XXXIX. Hydrocharidaceæ. XL. Naiadaceæ. XLI. Zosteraceæ.

SECTION 3.—FLOWERS WITH A TRUE CALYX AND COROLLA ADHERENT TO THE OVARY, UINSEXUAL.

11. NARCISSALS.	Flowers unisexual, with true calyx and corolla, adherent to the ovary. Stamens three to six, or more, all perfect seeds, with albumen. Some of the Bromeliaceæ have the calyx free, but so fleshy and permanent as to have all the appearance of being adherent to the ovary.	XLII. Bromeliaceæ. XLIII. Taccaceæ. XLIV. Hæmodoraceæ. XLV. Hypoxidaceæ XLVI. Amaryllidaceæ. XLVII. Ividaceæ.
12. AMOMALS.	Flowers unsymmetrical, with one to five stamens, some of which are petaloid; seeds with albumen; differs from Narcissals in having the veins of the leaves diverging, including the Musa, Ginger Curcuman, Cardamoms, Cannas, and Calatheas.	XLVIII. Musaceæ. XLIX. Zingiberaceæ. L. Marantaceæ.
13. ORCHIDALS.	Flowers unsymmetrical; stamens, one to three; seeds without albumen; embryo, a solid homogeneous body, destitute of visible tyledon.	LI. Burmanniac LII. Orchidaceæ.

SECTION 4.—FLOWERS WITH TRUE CALYX AND COROLLA FROM THE OVARY.

14. XYRIDALS.	Flowers half herbaceous, tripetalous, and hypogynous, with copious albumen. Embryo axile, on a fleshy albumen; in Philydraceæ minute, on the outside of fleshy albumen; half emerged in Commelynaceæ; minute and outside in Mayaceæ.	LIV. Philydraceæ. LV. Xyridaceæ. LVI. Commelynaceæ. LVII. Mayaceæ.

15. JUNCALES.	The rushes have flowers herbaceous, dry, and permanent, hypogynous, bisexual, scaly, scarious, if coloured; albumen copious; embryo, minute and undivided in the Rushes; axile with a cleft on one side in the Orontiaceæ.	LVIII. Juncaceæ LIX. Orontiaceæ.
16. LILIALES.	Flowers hexapetaloid, succulent, withering, albumen copious. Perianth surrounded by a calycine, involucres, inner bracts, coloured, and petaloid in Gilliesiaceæ, naked and flat when withering; anthers turned outward in Melanthaceæ, anthers turned inward in Liliaceæ; perianth naked; circinate anthers turned inwards in Pontederaceæ.	LX. Gilliesiaceæ. LXI. Melanthaceæ. LXII. Liliaceæ. LXIII. Pontederaceæ.
17. ALISMALES.	Flowers, three, six petalous, hypogynous, with separate carpels, without albumen; sometimes bisexual; many-seeded in Butomaceæ; few-seeded, simple, and axial, with solid embryo in Alismaceæ; flower scaly, few-seeded, simple, and axial, with large plumula in Juncaginaceæ.	LXIV. Butomaceæ. LXV. Alismaceæ. LXVI. Juncaginaceæ.

GLUMACEOUS PLANTS.

So called from their flowers being composed of bracts and not collected in whorls, but consisting of imbricated colourless or herbaceous scales. The grasses and sedges of which they consist constitute a very large proportion of the vegetation of the globe, covering our fields with verdure, and furnishing food for man and beast. They are provided with stamens and pistils, which are indispensable to the production of seeds, but there is scarcely a trace of calyx or corolla. This division of Endogens is thus distinguished: the *Graminaceæ* by their roots, generally fibrous, their round, hollow, and prominently jointed stems, their slender, parallel ribbed leaves with slit sheaths; the *Cyperaceæ*, or sedges, by their creeping roots, angular and solid stems, and inconspicuous joints; the *Juncaceæ* by their round tapering stems, and many-seeded capsular fruits; the *Eriocaulaceæ*, by their angular stem and capitate inflorescence; the *Typhaceæ*, by their erect tapering stem and densile spiked inflorescence; and in the arums or *Araceæ*, by their foliage dilated in *A. maculatum*, with scented leaves and succulent fruit in *A. corus*.

THE GRAMINACEÆ, OR GRASSES.—The important family of grasses, to which the Oat-grass belongs, supplies us also with Wheat, Rice, Rye, Barley, Maize, and the Sugar-cane; and constitute, besides, the grass of our meadows and our hill-sides. The Oat is an annual, the lower stem of which forms a short rhizome, from which secondary stems emanate: these are interrupted by brown inflated nodes or joints, which become solid, whilst the parts inter-

vening between the knots are hollow tubes. From these knots spring the leaves. Their petioles form a split sheath on one side, which embraces the stem for some distance before spreading out into a very long slender leaf, traversed by parallel and simple veins, converging towards the summit. At the point where the leaf separates from the sheath, we find a small, whitish, membranous band, which appears to be a continuation of the inner lining of the petiole beyond the origin of the lamina of the leaf. In the accompanying engraving (Fig. 350), of an annual grass, *Poa annua*, *s* is the sheathing petiole, called *ligula* (shoe-latchet), *l a* the lamina, *n* the tumid node, at which the leaf originates.

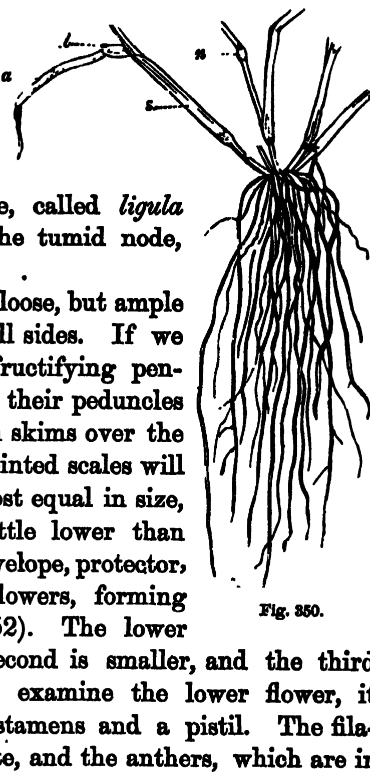


Fig. 350.

The infloresence of the Oat is a loose, but ample panicle, displaying branches on all sides. If we examine more closely these little fructifying pendants, which from the delicacy of their peduncles oscillate freely to the breeze which skims over the surface of the field of oats, two pointed scales will be observed on the outside, almost equal in size, but one of which is inserted a little lower than the other; this constitutes the envelope, protector, or glume of three distichous flowers, forming a little ear or spikelet (Fig. 352). The lower flower is fully developed, the second is smaller, and the third rudimentary and sterile. If we examine the lower flower, it is composed essentially of three stamens and a pistil. The filaments of the stamens are delicate, and the anthers, which are in the shape of an X, are loosely attached by the back. The pistil is composed of a shaggy, hairy ovarum, which surmounts the feathered styles. There is only one cell in the interior, containing an unique and *anatropal* ovule. These essential organs are protected by a system of two scales, the external or lowest of which bears upon its back a caducous and rigid filament, slightly bent, while the internal one, which is much smaller, is supplied with two lateral veins. This system constitutes the glume. In addition

to this we find on the outside of the exterior stamen two small collateral and fleshy bodies, which are designated a *paleole*.

When the ovule has been subjected to the fertilising influence of the pollen-tubes, it is transformed into a seed, which presents this peculiarity, that it is blended firmly with the fruit by its integument in such a manner as to constitute what botanists call *cariopsis*—a term used when the pericarp of an indehiscent seed-vessel is membranous, and adheres firmly to the integument, as in Fig. 351, which represents a cariopsis of Buckwheat (*Polygonum Fagopyrum*), which is often confounded with the seed itself. The greater part of this is composed of a farinaceous albumen. On the outside and beneath, a small distinct body is perceptible, sunk in the surface, and scarcely projecting from it. This is the embryo which, supported upon the albumen by it, forms a cushion-like enlargement by the lateral expansion of the stalks.

Fig 351.

WHEAT (*Triticum sativum*), originally from Persia, has trifloral spikelets; their sides opposite the axis, and disposed, as we know, in ears.

Fig. 352.—The cultivated Oat.

Rice (*Oryza sativa*), originally from India, presents a panicle of rigid and erect branches, with unifloral spikelets, the flower presenting six stamens.

Maize (*Zea*) is monœceous—that is to say, it presents both the sexual organs upon the same stalk. The flowers with stamens are disposed in a terminal panicle. The flowers with pistils have their spikelets close together, the lateral arm enclosed in a large spatha, which is nothing but the sheathing petiole of a leaf deprived of its limb. The stigma of these pistils are thread-like and very long. The *ensemble* of these stigma is like a handful of long filaments, hung carelessly towards the earth like a tuft of hair. The names of Turkish, Spanish, and Guinea wheat and Indian corn, which have been given to Maize, are quite fallacious, for it is indigenous to the tropics of America. With the exception of Wheat and Rice, Maize is the most useful as well as the most universally cultivated of the grasses. Almost all Asiatics, Africans, and Americans use it as their chief nourishment. The Sugar Cane, another plant of the Antilles, furnishes us with sugar for domestic purposes.

The Graminaceæ, in its 4,000 species, comprehends our most valuable plants for pasture, and all those which yield corn; their structure is the most simple of the higher forms of vegetation. Their stems constitute so many protecting sheaths to the rapidly growing shoots, and are clothed with alternate leaves; the inflorescence comprehends a small number of stamens and a single seed enclosed in a thin pericarp; the floral leaves, or glumes, are present in immense varieties in the different tribes, and form, with the number of stamens, texture, and sexual relations, very distinctive characters by which the several genera have been formed into tribes or families. Endlicher divides the 234 genera, of which the order consisted when he wrote (which is now increased to 291), into thirteen tribes, as follows:—

I. Oryzeæ.	Spikelets 1, 2, 3-flowered, lower floret one palea, and neuter, the upper only fertile.	16 genera, containing the Rice plant and some other interesting species.
II. Phalarideæ.	Spikelets hermaphrodite, 1, 2, 3-flowered, glumes equal, palea hardened and shining.	Containing 21 genera, including *Zea*, the Maize plant, and some pretty flowering plants.
III. Paniceæ.	Spikelets two-flowered, the lower incomplete; glumes thin, often abortive; paleæ coriaceous, awnless: compressed cariopsis.	Containing 38 genera, varying in height from the minute to the tall arborescent Panicum, which rises to the height of a lofty tree in India, with a stem as slender as a goose quill.

IV. STIPEÆ.	Spikelets one-flowered, lower palese rolled inwards, awn simple, articulated at the base, fruit indurated.	tells us was with ladies.
V. AGROSTIDEÆ.	Spikelets one-flowered; glumes and paleæ two, membranous and herbaceous; stigma sessile.	17 genera, including the Bent grasses and many curious genera of easy culture.
VI. ARUNDINEÆ.	Spikelet one or many-flowered, with the indications of an upper floret. Florets surrounded with long hairs; glumes as long as the florets.	12 genera, usually tall grasses, of reed-like appearance. *Arundo donax* is grown in France and Italy for fencing, vine-poles, fishing-rods, &c.
VII. PAPPOPHOREÆ.	Spikelets two, many-flowered, upper withering; glumes and paleæ two, inflorescence panicled.	10 genera of obscure and valueless plants, including the curious bearded Amphiphogan of Australia.
VIII. CHLORIDEÆ.	Spikelets unilateral, many-flowered, upper florets withering, glumes and paleæ two, spikes panicled, glumes permanent on the rachis, which is continuous.	28 genera of insignificant grasses, chiefly intertropical.
IX. AVENEÆ.	Oat grasses; spikelets containing two or several perfect florets; panicle branching, open, rarely in clusters, or spike-like; glumes two, paleæ two, and awned, awn dorsal and twisted.	28 genera, including the cultivated Oat and many other species of less interest.
X. FESTUCEÆ.	Pasture grasses; spikelets many-flowered, glumes two, paleæ two, with awn, panicle branched and spreading.	52 genera of grasses, including *Poa*, celebrated for pasture, and *Eragrostis* for its graceful dancing spikelets, and *Bambusa* for its canes.
XI. HORDEÆ.	Barley plants; spikelet one, three, and many-flowered, terminal floret withering; glumes two, sometimes absent, paleæ two, ovary hairy, inflorescence spiked.	8 genera, including Wheat (*Triticum*), Barley (*Hordeum*), Rye-grass (*Solium*), Rye.
XII. POTTBOELLEÆ.	Spikelets one, two, rarely three-flowered; inflorescence spiked, lodged in the hollows of the jointed rachis, glumes one or two.	13 genera, generally of insignificant grasses, including *Tripsacum*, the forage grasses of the West Indies.
XIII. ANDROPOGONEÆ.	Spikelets two-flowered, lower floret incomplete, paleæ transparent, and thinner than the glumes.	32 genera, including the Sugar-cane (*Saccharum*), and many pretty grasses cultivated in hothouses.

The vast family of Endogens is universally diffused. "*Agrostis algeda* was found by Phipps on Spitzbergen," says Babington. "On the mountains of the south of Europe *Poa disticha* and other grasses ascend almost to the snow line; and this is also the case on the Andes with *P. dactyloides*, *Dryeuxia rigida*, and *Festuca Dasyantha*." Their different dimensions are equally striking. Some species of *Bambusa* are 50 to 60 feet high; in these islands we are better acquainted with them as forming the compact grassy turf of our meadows, lawns, and hayfields.

It would be impossible to exaggerate the importance of this great family of plants. Most of them contain abundance of wholesome fæcula, and comparatively few of them are objectionable, although the cereal grasses only are cultivated for human food. Those reckoned deleterious may be briefly enumerated. *Lolium temulentum*, a common weed in many parts of Britain, is said to be injurious to cattle. *Bromus purgans* and *catharticus* are emetic and purgative.

Bromus mollis is also unwholesome; and *Festuca quadradentata* is said to be poisonous. *Molinia varia* is also injurious to cattle. The most esteemed pasture grasses are *Lolium perenne, Phleum* and *Festuca pratensis, Cynosurus cristatus,* with several species of Poa and Dwarf *Festuca,* to which the fragrance of the sweet Vernal Grass (*Anoxanthum*) add their fine aroma.

The CYPERACEÆ (Sedges) are Grass-like herbs, of solid angular stems, sometimes terminating at the base in corms or tubers, with narrow, tapering leaves wrapping round the stem, but without the slitting sheath. The flowers are imbricated solitary bracts, without calyx, the lowermost of which are often empty, very rarely enclosing other opposite bracts at right angles with the first, called glumes. There is no diaphragm at the articulations; the seed has its embryo, lying in the base of the albumen, within which its cotyledonous extremity is enclosed.

The Sedges are found in ditches, marshes, and running streams, heaths and forests, on the sands of the seashore, and on the tops of mountains. In Lapland, according to Humboldt, they are equal to grasses in number; but from the temperate zone to the equator the proportion decreases. As we approach the equatorial regions the character of the order changes—*Carex Scirpus* and *Schœnus* give place to the *Cyperaceæ* and other analogous genera. On the banks of the Nile, and in many parts of Arabia, the *Papyrus antiquorum* grows, of which boats, paper, and ropes are made; and *P. corymbasis* is equally useful in India, where it is manufactured into matting for rooms; while *Cyperus textilis* makes a kind of rope much used in the East.

Of the remaining orders constituting glumaceous plants the DESVAUXIACEÆ consist of genera of small tuft-like herbs, distinguished from the Sedges by their ovaries, which are variable in number and distinct from each other, ranged round a common axis, as in the Ranunculus. They are insignificant plants of the South Sea Islands and Australia.

The RESTIACEÆ are herbaceous under shrubs, with naked stems, or protected by slit sheaths, flowers in spikes, separated by bracts and generally unisexual. They are distinguishable by their pendulous seed and lenticular embryo at the extremity of the seed opposite to the umbilicus, by their thin stamens placed opposite the

inner glumes, their simple unilocular anthers, their glumaceous flowers, and their membranous sheath between the glumes and the ovary. They are natives of the woods and marshes of New Holland and South Africa.

The ERIOCAULACEÆ are perennial marsh plants with cellular spongy leaves sheathing at the base, very minute capitate and bracteate flowers. Glumes two, and unilateral, a membranous tube, anthers two-celled, and in the Xyrids a perfect corolla, connecting them with the higher organised Endogens. They are chiefly aquatic, two-thirds of them natives of tropical America, a sixth are Australian, and the remainder North American. One species is found in the Island of Skye.

Passing over many Endogens of secondary interest, the several orders of which are enumerated in the brief summary we have given of them, we reach the Palms, the culminating point of vegetative power in Endogens.

The PALMACEÆ are for the most part trees of gigantic growth, always forming wood and occasionally reaching dimensions altogether unknown among other plants. The Calami or Rotans, for instance, according to Humphries, are sometimes 1,200, and even 1,800 feet long, rising to the tops of the highest trees and falling again. The Palms occupy their place in the first ranks of vegetation as much by the majestic beauty and elegance of their appearance, as for their services to the inhabitants of the tropics, to whom they furnish at once bread, oil, and wine. Let us examine the Date Palm as a type of this vegetable group.

This beautiful tree (represented in Fig. 353), which has deservedly received the name of the Prince of Vegetables, raises its straight and column-like stem from eighty to ninety feet. It is crowned by an ample tuft of from forty to fifty leaves, which sometimes attain the length of ten or twelve feet, floating from the summit in rigid, linear, lanceolate, sword-shaped folioles, each arranged like the fringes of a feather. From the axils of the leaves issue coriaceous *spathes* of a single piece, which opens on one side and permits the passage of long branchy panicles, which ultimately bear small flowers, which are generally male on one tree and female on another, for it is to be noted that the Date Palms

are diœceous trees, and it is well known that in order to produce

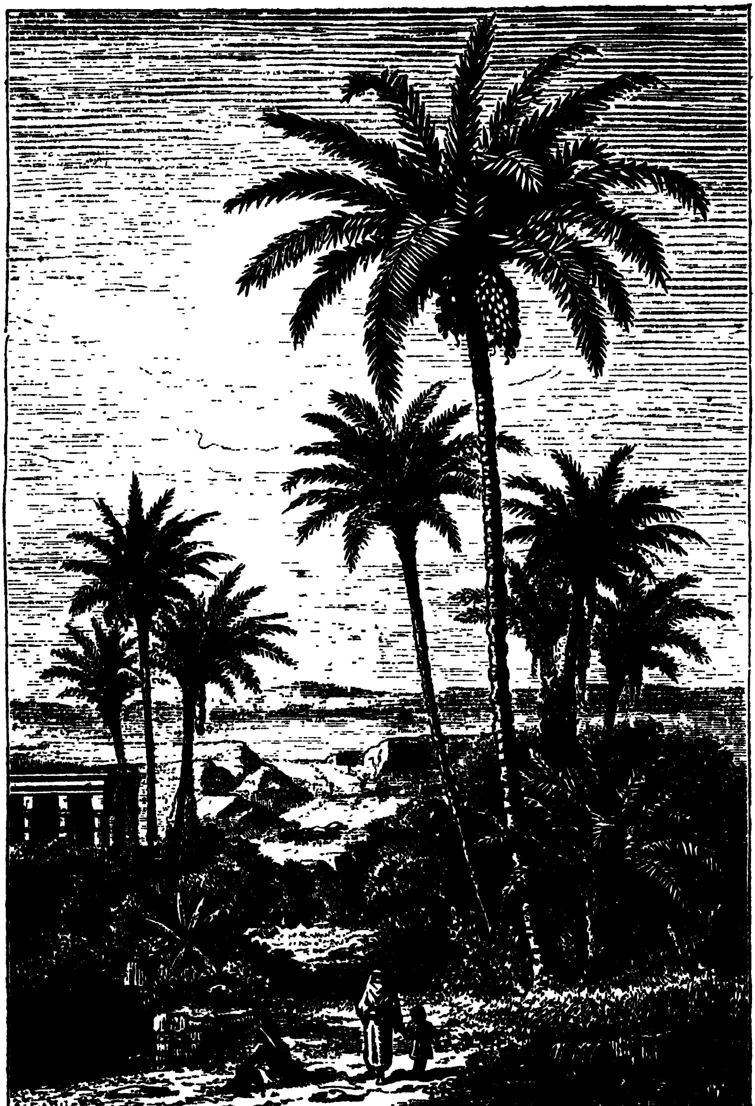


Fig. 353.—The Date Palm.

fruit from this tree, it is usual to have recourse to artificial impreg-

nation of the female flowers, a practice which has been carried on from the earliest times in the countries where the date is cultivated. The male flower of the Date Tree is borne on a very short sepalous calyx; has a thin petalous corolla much larger, with six stamens, furnished with long linear anthers, the two cells of which open themselves from within by two longitudinal slits.

The female flowers present a double floral envelope, each whorl of which is formed of three pieces, forming three distinct pistils, each surmounted by a stigmata in the form of a hook.

Of these three pistils one only develops itself, ripens, and becomes an elongated, ovid berry, with a slight epidermis of a yellowish red, a solid and slightly viscous pulp, and an endocarp represented by a slight pellicle enveloping the nucleus, which is the seed. This seed is cylindrical, growing thinner at its two extremities, deeply grooved in its whole length on one side, and presenting in the middle of the other a small circular depression—an operculum, which is destined to fall out at the moment of germination to let out the radicle germs, in the manner described in the chapter on Germination, in speaking of the Indian Shot. In short, this operculum corresponds to a little hollow where the germ is placed in such a manner that its great axis (if one can speak of the great axis of such a little thing) is perpendicular to the surface of the seed. It will be seen, in conclusion, from Fig. 354, which gives a representation of the seed of a Date, that it is almost entirely composed of a hard horny albuminous substance, the thick walled cells of which are filled with albuminous and fatty matter.

Fig. 354.—Seed of Dates.

The Date Tree, indigenous to Arabia and the north of Africa, is pre-eminently the tree of the oasis of the desert; that which, according to the allegorical language of the Orientals, plunges its foot into the water and its head into the fires of heaven. It is planted as an ornamental tree in Corsica, Sardinia, and in the north of Italy, but it does not ripen in these countries, or only imperfectly. By incisions in the trunk of the Date Palm a sweet liquid is obtained which is called the milk of the Palm Tree, which after being subject to fermentation takes a vinous flavour. When distilled, this liquid furnishes

a very pleasing alcohol. The stem of the same tree supplies the natives with their wood for firing and construction, its leaves are employed to roof their houses, and from its folioles negroes manufacture baskets, mats, hats, &c. The compass of this work will not permit us to give the history of the different species of Palms, which are so numerous and so interesting, from their structure, beauty, and utility. We must confine ourselves to the mention of those whose form is the most remarkable.

The Cocoa-nut Tree (*Cocos nucifera*) is an inhabitant of the whole torrid zones, chiefly in the neighbourhood of the seas. It rises to the height of a hundred feet, and is surmounted by a crest of pinnated leaves resembling a bunch of feathers about twelve feet long; the fruit is a drupe as large as the head of a man, with a fibrous mesocarpe and a bony endocarpe; the seed is almost entirely formed of a fleshy white albumen; in the interior the centre of this albumen is occupied by a clear liquid, an agreeable and refreshing beverage, a sort of vegetable milk. A fixed oil is obtained from the Cocoa-nut Tree; every part of the tree, in short, is useful to man, either to clothe, feed, or shelter him.

We borrow from Bonifas-Guizot's Botany for Youth the following passage, which, whether allegorical or the experiences of an actual traveller, gives with some piquancy an idea of the infinitely varied advantages which the inhabitants of tropical countries draw from the Cocoa-nut Tree and its products:—"Imagine a traveller passing through one of these countries, situated under a burning sky, where coolness and shade are so rare, and where habitations, in which to take the repose so necessary to the traveller, are only to be found at considerable distances. Panting and dispirited, the poor traveller at length perceives a hut surrounded by some trees with straight, erect stems, surmounted by an immense tuft of great leaves, some being upright and the others pendent, giving an elegant and agreeable aspect to the scene. Nothing else near the cabin indicates cultivated land.

"At this sight the spirits of the traveller revive; he collects his strength, and is soon beneath the hospitable roof. His host offers him a sourish drink, with which he slakes his thirst: it refreshes him. When he has taken some repose, the Indian invites him to share his repast. He serves up various meats, con-

tained in a brown-looking vessel, smooth and glossy; he serves also some wine of an extremely agreeable flavour. Towards the end of the repast his host offers him certain succulent comforts, and he is made to taste some excellent spirits. The astonished traveller asks who in this desert country furnishes him with all these things. 'My cocoa-nut tree,' is the reply. 'The water I presented you with on your arrival is drawn from the fruit before it is ripe, and some of the nuts which contain it weigh three or four pounds. This almond, so delicate in its flavour, is the fruit when ripe. This milk which you find so agreeable is drawn from the nut; this cabbage, whose flavour is so delicate, is the top of the Cocoa-nut, but we rarely regale ourselves with this delicacy, for the tree from which the cabbage is cut dies soon after. This wine, with which you are so satisfied, is still furnished by the Cocoa-nut tree. In order to obtain it an incision is made into the *spathe* of the flowers. It flows from it in a white liquor, which is gathered in proper vessels, and we call it palm-wine; exposed to the sun, it gets sour and turns to vinegar. By distillation we obtain this very good brandy which you have tasted. The sap has supplied the sugar with which these preserves are sweetened. These vessels and utensils have been made out of the shell of the nut. Nor is this all: this habitation itself I owe entirely to these invaluable trees; with their wood my cabin is constructed; their leaves, dried and plaited, form the roof; made into an umbrella, they shelter me from the sun in my walks; the clothes which cover me are woven out of the filaments of their leaves. These mats, which serve so many useful purposes, proceed from them also. The sifter which you behold was found made to my hand in that part of the tree whence the leaves issue; with those same leaves woven together we can make sails for ships; the species of fibre that envelops the nut is much preferable to tow for caulking ships; it does not rot in the water, and it swells in imbibing it; it makes excellent string, and all sorts of cable and cordage. Finally, the delicate oil that has seasoned many of our meats, and that which burns in my lamp, is expressed from the fresh kernel.'"

The stranger would listen with astonishment to the poor Indian, who, having only his Cocoa-nut tree, had nearly everything which was necessary for his existence. When the traveller was disposed

to take his departure, his host again addressed him: "I am about to write to a friend I have in the city. May I ask you to charge yourself with my communication?" "Yes; but will your Cocoa-nut tree still supply you with what you want?" "Certainly," said the Indian; "with the saw-dust from severing the leaves I made this ink, and with the leaves this parchment; in former times it was used to record all public and memorable acts."

In the great conservatories of Kew, of the Museum de Paris, and of St. Petersburg, magnificent specimens of Palms are cultivated, which flourish there and fructify frequently. One of these is shown in Fig. 8, one of the two species of *Chamærops humilis* which decorate the entrance to the Jardin des Plantes at Paris. This species is indigenous to the south of Europe; the others belong almost exclusively to the torrid zone, and to the warmer regions of the temperate zone. The species of Chamærops are numerous in India, and the Indian Archipelago. They swarm in equatorial America, but are comparatively rare on the African continent in consequence of the long periods of dry weather to which the climate is subject. Another species of Palm, extremely well known in Central America, and which forms immense forests in Brazil, is the *Mauritia flexuosa*, represented in Fig. 355.

The Avoira Palm (*Elais Guineensis*) is a magnificent tree, originally from Guinea, from whence it has been transported to Asia and America. Its fruit, which is about the size of an olive, is of a golden yellow, and filled with a liquid oil known under the name of palm oil, which serves for the manufacture of soap, and is imported to Europe for that purpose, being one of the principal objects of exportation from the east coast of Africa.

The Sago Tree (*Sagus rhumphii*), originally from the Malacca Isles, contains in its often voluminous stem a very nourishing fecula; but the finest sago is said to be prepared from *S. lævis* and *genuina*.

The Arec Palm (*Areca catechu*), indigenous to India and Ceylon, furnishes a highly valuable catechu. The albumen of its seed, cut up in slices, powdered with chalk, and enclosed in a leaf of the Betel tree, is much used by native Indians to facilitate digestion. Another species of Arec (*Areca oleracea*) is particularly esteemed for the excellence of its large and tender

young shoots, commonly known under the name of the Palm Cabbage.

Fig. 55.—Mauritia flexuosa.

The Rotang (*Calamus*) has a slight stem, few or no leaves, but climbers, by means of which it sometimes extends itself along the

whole length of a tree, passing from one branch to another for a length of 1,500 to 1,800 feet; from this tree the polished and flexible canes are made, known by the name of Malacca canes.

The Ceroscyle of the Andes (*Ceroscylon Andicola*), the trunk of which in Persia rises to a height of 200 feet, produces a wax, which exudes from its leaves and from the base of its petioles.

The Narcissals.

Passing over the Hydrales, which are represented by the Hydrocharidaceæ,—floating water plants with exalbuminous seeds and declinous flowers; natives of fresh water in Europe, North America, and the East Indies;—the Naiads, inhabiting both fresh water and the ocean, in which traces of the great class of Thallogens are still observable;—the small perennial Tricoredaceæ, with creeping rhizome and simple erect and cellular stem;—the Torteraceæ, or sea-wracks, whose habitat is the bottom of the ocean in the Mediterranean and the Indian Ocean,—we reach the Narcissals.

The Narcissals are distinguished from all preceding Endogens by their short stem, rigid channeled leaves, often covered with cubicular scales, spinous points, and flowers of gay colour, borne in racemes or panicles in the *Bromeliaceæ*, of which the most remarkable species is the well-known Pine-apple, celebrated for the sweetness and aroma of its fruit.

The tuberous rooted Taccaceæ are large perennial herbs, found in damp woods in the hotter parts of India, in the South-Sea Islands, and in the tropical parts of Africa. The Hæmodoraceæ are herbaceous plants, with fibrous perennial roots, and permanent sword-shaped leaves and woolly flowers; natives chiefly of North America, the Cape of Good Hope, and Australia. The Hypoxidaceæ is an inconsiderable order of herbaceous plants, with tuberous or fibrous perennial roots, natives of the Cape of Good Hope, Australia, the East Indies, and tropical America.

The Amaryllidaceæ are generally bulbous plants, occasionally fibrous rooted, with a tall cylindrical woody stem, ensiform leaves with parallel veins,—singularly elegant plants, which have long been the favourite inhabitants of the greenhouses. The order

includes the Daffodil, the Belladonna and Guernsey Lily, the showy Brunsvigias and Blood-flowers (*Hæmanthus*) of the Cape of Good Hope, and the American Aloe—all characterised by their six stamens, a brilliantly coloured flower, and inferior ovary. With all their beauty, however, there is no family of plants possessed of more noxious properties. The viscid gum drawn from the bulb of *Hæmanthus toxicarius* is used by the natives of South Africa to poison their arrow-heads. The common daffodil and snow-drop contain an acrid principle which renders them emetic. The flowers of Narcissus (pseudo-Narcissus) are not only emetic, but a dangerous poison. On the other hand, many of them possess fine medicinal properties, and from the succulent root of *Alstræmera palida* fine arrow-root is prepared. Others of the tribe, as *Bomarea salsilla*, yield a substitute for sarsaparilla. The American Aloe (*Agave Americana*), which according to gardening fable only blooms once in a hundred years, forms an impenetrable fence with its hard spinous leaves, while its fibre forms excellent cordage after being steeped in water for some time, and the succulent substance beat out of it. In Mexico, where the aloe is extensively cultivated, sap of an agreeable sourish taste is drawn from it by cutting out the inner leaves just before the flower-scape is ready to burst forth. This sap, when fermented, forms a vinous beverage, resembling cider, called "pulque," while by distillation a very intoxicating liquor is made from the pulque. This sap yields a very considerable revenue to the State.

The IRIDACEÆ connect the Narcissals with the Plantains and Bananas, or Amomals; the chief external distinction between the two being a singular change in the development of the foliage. In the Narcissals, and especially in the Iris and Gladioles, the leaves are long, slender, and sword-shaped, with the veins running in parallel lines converging to the apex; but in the Musaceæ and other Amomals, the veins run perpendicular to the midrib—a divergence which gives to the foliage a totally different character.

The Irids are herbaceous Endogens, in which the exterior envelope of the flower or the calyx is composed of three stamens, with the anthers turned outward, and opposite to them three richly-coloured sepals, recurving outwardly, as shown in Fig. 356,

where *s s s* represent the three reflexed or bent-back richly-coloured sepals, and *p p p* the erect petals at the summit of the flower. These six divisions, which are free in the young plant, and arranged in two rows, are afterwards united, and form a perianth of singular appearance, taking a tube-like form towards the base. On depressing the sepals, three stamens with broad flattened filaments and elongated anthers, bifurcated in the form of an arrow-head, are observed opening in two longitudinal grooves filled with voluminous pollen seeds. These stamens, which are at first completely independent of the perianth, are united in the adult state to that organ. The pistil consists of an inferior ovary united to a style attached by its base to the foot of the tube of the perianth, and terminating in three petaloid stigmatiferous leaves. The ovary presents three cells, enclosing numerous ovules attached to its middle, or anatropally disposed in two series placed at the internal angle of each cell. The fruit is capsular, and opens into three distinct portions, divided by valves at the centre. Fig. 357 shows this loculicidal dehiscence, the valves with the septæ in the centre, each valve being formed of the half of the contigucus carpel. The seeds being horizontal and flattened, present a straight embryo placed in an axis of fleshy albumen.

Fig 356
Petals and Sepals of the Iris.

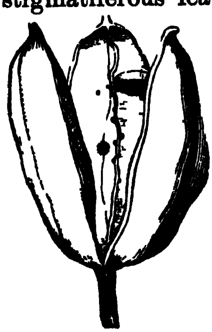


Fig 357.
Capsule of the Iris.

The Iris has a thick, branching, fleshy, horizontal phizome, a simple or branching stem. The leaves are for the most part in fasciculate radicles folding longitudinally, and attached nearly in their whole length by the two halves of their internal face. The

central veins correspond with the outer edge. The cauline leaves are alternate and sheathing. The flowers form a sort of composite cluster, which are of great volume, and exhale a most agreeable odour.

The genera are numerous, inhabiting all the temperate parts of

Fig 358.—Iris Germanica

the world; the Iris and Crocus representing the order in the northern, as the brilliant Gladioles and Ixias do in the southern

hemisphere. Most of the genera are strikingly beautiful, the number and brilliancy of the varieties in the Gladiolii by cultivation alone being almost unexampled.

Among the interesting species which constitute the genus *Iris* we may mention the *Iris Germanica* (Fig. 358); the *Iris Florentina*, the rhizome of which produces the violet-scented orris root, and gives out a very decided odour of violets, which causes it to be used extensively in preparing perfumery. The cultivated Saffron, *Crocus sativas*, is a native species, the stigmata of which form a crest containing a very odorous volatile oil united with a bitter principle; it is employed in medicine, and also in painting. The GLADIOLES have bi-labiate flowers of great brilliancy; they are chiefly natives of Southern Africa.

TIGRIDIA PAVONIA, so called from its spotted and brilliantly coloured flowers, is another of the Bulbous plants for which we are indebted to tropical America. It is a native of Mexico, remarkable at once for its large size, originality of form, and lively colours.

ORCHIDACEÆ.

Passing over the MUSACEÆ, so celebrated for the nutritive food yielded by their fruit, known in tropical countries as plantains and bananas; the ZINZIBERACÆ, distinguished for the beauty of their floral appendages, as in *Hedychium coronarium*, and for the rich and glowing colours of the bracts in *Curcuma Roscæana*—they are still more valued for the aromatic stimulating properties of their rhizome;—the MARANTACEÆ, valued for the fæcula which abounds in the rhizome and fleshy corms of *Canna* and some other genera,—we reach the interesting family of ORCHIDS. The ORCHIDACEÆ are a group of Epigynous Endogens, with one to three stamens, consolidated with the style into a central column, and the seeds without albumen. They are herbaceous plants or shrubs, always perennial, and they occur in all parts of the world, but in the warmer latitudes they occur in countless numbers. In the forests of tropical America, in the Indian Archipelago, and in India and other hot countries, they generally are epiphytal; attaching themselves to the branches of trees, stones, and rocks, to

ground as in the ORCHIS. (2) Fleshy tubercles, having a bud at their extremities containing amylaceous granules for the nutrition of the plant. (3) Fleshy branching bodies of tortuous and

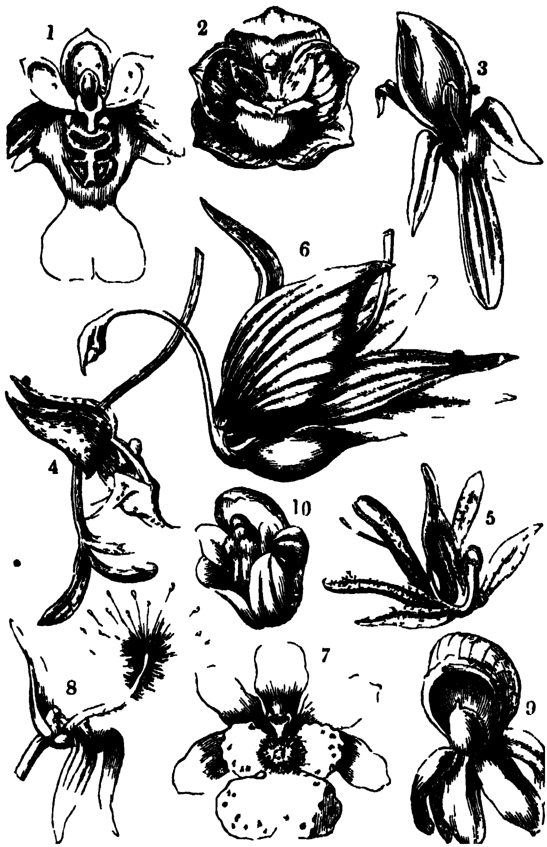


Fig 359 —Forms of Orchidaceous Flowers

angular form, as in *Neottia*, or resembling tubers, as in *Gastrodia*. (4) Simple or branched shoots, capable of extension, protruding from the stem into the air, and formed of a woody and vascular axis, covered with cellular tissue, the subcutaneous layer being often green, and composed of large reticulated cells, the points of the roots being usually green, but sometimes red or yellow.

The stem is in its simplest state in *Ophrydeæ*, where it is only a

growing point surrounded by scales, and constituting a leaf-bud when at rest, which eventually grows into a secondary stem or branch in which leaves and flowers are developed. This kind of stem develops every year a lateral bud with a tubercular root attached, which, after unfolding its flowers and ripening its fruit, perishes, to be succeeded by the stem belonging to the lateral bud; hence the species having this kind of stem has always a pair of tubercles attached, one shrivelling and in process of exhaustion, the other swelling and progressing towards completion. The leaves are uncertain,—usually they are sheathing at the base, and membranous; but in *Vanilla* they are hard, stalked, articulated at the base, and have no trace of a sheath. Sometimes they are leathery and veinless, frequently they are membranous and strongly ribbed, especially in *Maxillaria* and *Cypripedium*.

"The floral envelopes are constructed upon a ternary type, and consist of three exterior and three interior pieces, the exterior being nearly equal, but less brilliantly coloured than the interior, but the two lateral ones are often of a somewhat different form from the other, which is anterior when young, but becomes posterior when the flower expands, in consequence of the flower-stalk becoming twisted or curved.

"The centre of the flower is occupied by a body called the Colusan, which is formed by consolidation of style and stamens, of which there are, in the greater part of the order, only one present, which is placed opposite the intermediate sepal, and, consequently, alternate with the petals, but in *Cypripedium* there are two stamens. In the greater part of the order a single anther terminates the column. This is usually two-celled, but often has its cells divided into two or four other cavities by the extension of the Endothecium between the lobes of the pollen-masses, or it is occasionally more or less completely one-celled by the absorption of the connective."

The pollen consists of lenticular or spheroidal grains, either single or cohering in pairs, threes, or fours, or in larger masses in indefinite numbers; usually held together by an elastic filamentous substance, which either contracts on adhesion with a gland originating on the margin of the stigma, as in *Ophrydeæ*, *Neottieæ*, and *Vandeæ*, or it is folded upon the pollen-masses, as in

Epipendreæ or it terminates in an amorphous dilatation, as in many *Malaxideæ*.

These differences in the structure of the column, anther, and pollen, furnish botanists with the best means of classifying the order and breaking it into sub-orders, thus :—

I. MALAXIDEÆ.	Having the anthers free, opercular, or covered with a lid, pollen-masses waxy, with neither caudicula nor gland; roots thick and fleshy in Corallorhiza, bulbous in Liparis and Malaxis.	Including Pleurothallis, Liparis, Dendrobium, and Corallorhiza.
II. EPIDENDREÆ.	Anther opercular, pollen waxy, caudicula folded back upon the pollen grains, and no gland.	Including Epidendrum, Cœlogyne, Lælia, and Bletia.
III. VANDEÆ.	Anther opercular, pollen waxy, with a membranous caudicula and gland.	Including Vaunda, Sarcanthus, Cryptochilus, Brassia, Oncidium, Maxillaria, and Calantho.
IV. OPHRYDEÆ.	Anther erect, with distinct connection, pollen sectile or granular, forming an axis round which the masses of grains are arranged, sometimes forming a strap or caudicula.	Including Orchis, Serapias, Gymnadenia, Holothrix, Disa, and Corycium.
V. ARETHUSEÆ.	Anther opercular, pollen granular or powdery, lip slightly articulated with the column in some *Pterostylis*.	Including Limodorum, Acianthus, Catleya, Pogonia, Gastrodia, Vanilla, Pterostylis.
VI. NEOTTIEÆ.	Anther erect and dorsal, having the stigma in front, pollen powdery, having the caudicula adherent to a gland on the margin of the stigma.	Including Cranichis, Listera, Neottia, Spiranthes, Physurus, and Thelymitra.
VII. CYPRIPEDIEÆ.	Anthers two, separated by a broad sterile lobe.	Including Cypripedium only.

Among the MALAXIDEÆ we find many British species, as the coral-rooted *Corallorhiza crinata*, whose root gives out the scent of the vanilla when drying; *Liparis loeselli*, with its yellowish ten-flowered spike; but the more beautiful species of this sub-order are found among the Dendrobiums, an extensive genus of East Indian Epiphytes found in the moister parts of Asia, of tropical Japan and Australia.

The VANDEÆ have no representative among British Orchids. The Epidendrums, originally a name given to all Orchidaceous Epiphytes, are now restricted to a genus of the order having the labellum united to the column, and four pollen-masses adhering to as many little straps bent back upon them; a group containing some showy and interesting plants, but many of them inconspicuous and unimportant. Among the other genera, however, some of the most brilliant ornaments of the conservatory are found. The colours of some of the Cœlogynes are rich and delicate in hue—*C. cristata*, a dwarf evergreen species from Nepaul, throws out leaves six inches long and six or eight drooping spikes of flowers

of a delicate white with a blotch of yellow on the lip, each flower being three or four inches wide.

The CATTLEYAS are, however, the most striking of all the Orchids. Their dark evergreen foliage and compact habit recommend them especially to the cultivator. The flowers are large, elegant in form, and their prevailing colours, of violet, rose, crimson, and purple, are unsurpassed for depth and brilliancy. *C. granulosa*, from Brazil, produces large olive-coloured flowers, with rich brown spots; the lip whitish, spotted with crimson in *C. guttata*. *Leopoldii*, another Brazilian species, grows about twenty inches high with a dark green foliage. The sepals and petals are dark brown spotted with crimson, and purple lip. Others are rose-coloured, margined with white, or sepals and petals pure white, with beautifully fringed lip of richest crimson.

The LÆLIAS rival, while they resemble the Cattleyas; they are compact in growth, with evergreen foliage, producing their flowers in spikes from the top of the bulbs. In *L. acuminata*, from Mexico, the sepals and petals are white, and lip white with a dark blotch on the upper lip. In *L. anceps* the sepals and petals are rose lilac, and lip a beautiful purple, the flowers being three or four inches across; others purple, with a crimson lip, or delicate rose-colour, the lip striped and shotted chocolate brown, with flowers four inches across, as in *L. megalis*. In short, so far as graceful foliage, brilliancy of colouring, form and size of flowers are concerned, the Orchids of this division are the gems of the Vegetable World.

The VANDEÆ include many of the most curious and interesting among Orchids, chiefly Epiphytes.

The *Aerides* combine with their rich, evergreen, and gracefully curving stem and opposite leaves, flowers of peculiar elegance, proceeding from the axils of the leaves, and extending their rich and waxy petals in delicate racemes sometimes two feet in length, and yielding a most agreeable fragrance. The Aerides are natives of the hottest parts of India and other tropical countries, attaching themselves to trees, generally such as overhang running streams of water. *A. affine* throws out its pink and white flowers in long branching spikes two feet long. *A. cuspum*, another Indian species, with purple-coloured stem and dark green foliage, throws out long spikes of flowers of pure white tipped with pink. The *Saccolabiums*

closely resemble the Aerides in habit; their flowers are produced in long graceful racemes, often a foot and a half long, springing from the axils of the leaves.

Oncidium is another extensive genera belonging to the Vandeæ; they are chiefly natives of tropical America. The prevailing colour of their flowers is yellow spotted with rich reddish brown, and they are known by their broad labellum, more or less lobed, distinct from the column, and furnished at the base with a tuberculated disk, spreading sepals and petals, with a membranous ear on each side of the column, and two pollen-masses attached to a long caudicula, which give the plant a grotesque resemblance to the Butterfly, the name it bears. In their native forests these Epiphytes wholly overrun the trees, clasping them round, and covering them from top to bottom with their brilliant and grotesque flowers.

The OPHRYDEÆ have fleshy, bulbous roots, with radical fibres, leafy stem, anther continuous with the column, and the pollen-mass agglutinated and attenuated into a pedicel. In *Orchis* and *Gymnadenia* the lip has a spur, in *Ophrys* it is thick and spurless, in *Habenaria* the spur is very long; in *Aceras* the outer and inner divisions converging, form a hood, lip in three linear divisions and spurless. This and the following group are natives of temperate Europe, many of them of the British Islands.

As a representative of the family we may take the plant so well known in this country and in the north of France, commonly called the Flower of Pentecost, or the spotted Orchis, *Orchis maculata* (Fig. 360). The floral envelope of this species is composed of six petal-shaped pieces, disposed alternately in two rows (Fig. 361). Of the three exterior pieces, two are slightly lateral, the middle one is curved forward in such a manner as to form, with two divisions of the internal ventricle, a sort of casque or helmet. The third division has, on the contrary, a shape peculiar to itself; on the upper side it presents the appearance of a large hanging apron, prolonging itself below into a sort of spur. This is the *labellum*, or lower lip, of the flower. The corolla is then essentially irregular. When the six pieces of the floral envelope are removed a central column becomes visible, having in front two cells, the longitudinal openings of which face the apron. Below, an almost square cup, glossy and viscous, is observable. If we open these

cells with the point of a needle, it will be found that each of them contains a pyriform body, the upper part of which is inflated, and is composed of little angular masses, bound together by a sort of elastic network, while the lower part is lengthened into a kind of pedicel or foot-stalk. These two pedicels are inserted at their base in the contiguous compartments of a little pocket. If we depress one of these pyriform bodies towards the cup, it adheres there firmly. We may easily satisfy ourselves that the phenomenon is spontaneously produced in nature, and that the pollen-masses are discharged upon the viscous surface from the tubes, and that they quickly penetrate its tissues. This cup, then, is the *stigma*, these pyriform bodies the pollen-grains, and the two cells which enclose them constitute an anther. Thus, in this curious flower the Style and the Andrœcæum are united to form the central column, and it has only one stamen.

Fig. 300.—Orchis maculata

Beneath the point of insertion of the floral divisions, the column

is continued by a sort of greenish appendage, with six longitudinal ribs, much twisted when the flower is about to expand. This is the ovarium, which, as we see, is inferior. This ovarium presents one single cell, and encloses a great number of very small ovules inserted upon three placentæ attached to the internal walls of the ovary. The fruit is capsular, and opens by three valves, which bear the placentæ in their axis, whilst the midribs remain in their place, united at the base as well as at the summit. Let us now examine the organs of vegetation in the same plant. The parts which are under the ground consist of two unequal tubers (Fig. 362), one of which is wrinkled, soft, and apparently devoid of sap, whilst the other is whiter, larger, and much firmer. The substance of the first, in short, has been exhausted in the development of the aerial stem, which now bears its bunches of flowers; whilst the other is reserved for the development of the young leafy branch in the following year. These two tubers, which are ovoid or egg-shaped, are the nutritive roots. Above these roots is another little shoot, which will not be fully developed till two years later. In some other indigenous species—*Orchis latifolia*, for instance—the

Fig. 361.—Floral Envelope.

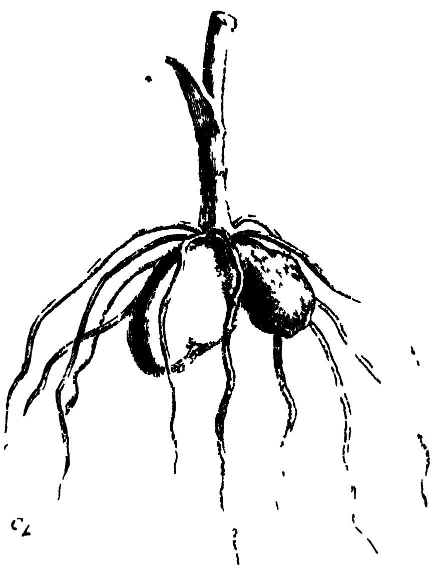


Fig. 362.—Tubers and Rootlets.

roots, instead of being ovoid, are palmate or hand-shaped. Both kinds of roots are accompanied by the ordinary cylindrical root-fibres, covered with hairs, whose principal function is absorption. The leaves of the *Orchis maculata* are sheathed and arranged spirally upon the stem; their lanceolated limbs are generally sprinkled with black spots. This study of an orchid, so frequently met with, will give a general idea of them. But to realise the appearance presented by the plants of this remarkable order, they must be seen or imagined as they appear in the tropical forests. Many of the tropical orchids are Epiphytes, but not always parasites—that is, they grow in the clefts of branches, and in the angles of roots, either erect or gracefully suspended from the branches, but without drawing their nourishment from them. Their flowers are disposed in ears, branches, or tufts, of different sizes, and their colours are often most rich and varied, frequently yielding a sweet perfume. They always present an original and somewhat fantastic appearance; now resembling a fly, now a spider, others a butterfly, and some a man suspended by the head. The diversity in the size and appearance of their flowers, and their strange beauty, cause this group of plants to be one of the most cherished ornaments of our hothouses.

The Arethuseæ are among the least interesting of orchids. Dr. Lindley once thought Vanilla of sufficient importance to constitute a sub-order, which he has since withdrawn. The Vanillaceæ are climbing orchids, but not Epiphytes; the leaves are fleshy, subcordate at the base, and articulated with the stem, which is square, and climbs to the height of 20 or 30 feet. The flowers are fleshy, the perianthe articulated with the ovarium; the sepals and petals nearly equal, and free at the base, the labellum is entire and united with the column; the anthers terminal and opercular; the pollen-masses, two, bilobed and granulose. There are eight species, two of them found in Asia and six in America. The fruits of most of them are aromatic, and there is still some doubt which of these species yield the Vanilla of commerce. It is supposed to be the product of several species; probably the fruit of *V. aromatica* and *V. planifortia*, said to contain so large a proportion of essential oil and benzoic acid as to intoxicate the labourers who gather it.

The NEOTTIEÆ are chiefly indigenous to this country, usually fibrous rooted, rarely a fleshy bulb, anthers distinct from the column, often parallel to the stigma, pollen-grains loosely coherent, nearly powdery. The species are generally small, being 6 to 15 inches high in the Bird's Nest Neottia, flowers and stem pale yellowish brown, on an oblong spike; column notched with two short beaks, and lobes of the lip divergent; an inhabitant of chalky, shady places. Lady's tresses, *Spiranthes*, bear small white flowers on a one-sided spike. Found in bogs in the New Forest.

The CYPRIPEDIEÆ are singularly beautiful in their foliage. The form of the flowers is curious, being slipper-shaped; hence their name of Lady's Slipper, of which we have one native species, found in the woods of the North of England, but very rare. The sepals are ribbed, of a rich dark-brown colour, the two lower ones united. Lip turned, yellow, and marbled, about an inch long, reticulated with veins, and spotted internally.

The exotic species are also dwarf species, but compact and evergreen, the leaves of many of them being beautifully spotted. *C. barbatum* is a pretty species, with beautifully spotted foliage; the colour of its solitary flowers brownish purple and white. In *C. barbatum grandiflorum* the foliage is finely variegated, and the flowers considerably larger than the preceding. *C. biflora* is an Indian species, with variegated foliage, four inches high. The blossoms produced on a spike ten inches long, the top petal being a beautiful white, and the other part of the flower a purplish-brown.

It will have been observed from the preceding remarks, that, besides the physiological differences in accordance with which botanists have arranged them, there is a distinct difference of habit; that a portion of them root in the soil and draw their support from the earth, while others attach themselves to trees, stones, and rocks, where they receive little or no support through their roots. The first, including such genera as *Phajus*, *Calanthe*, *Bletia*, *Cypripediums*, are known as TERRESTRIAL ORCHIDS. The others have sometimes been called AIR-PLANTS, but with greater propriety they are now termed EPIPHYTES. They grow chiefly upon other plants, adhering to their bark or rooting among the scanty soil that occupies their surface, not as parasites by striking adventitious roots into the wood and nourishing themselves upon

the sap of the individual to which they are attached, but using the tree apparently as a means of attaining a height where they can obtain the air and light, or the heat, moisture, and shade, as the case may be, necessary to their existence.

ORCHIDACEOUS EPIPHYTES are much the most numerous and interesting, and now that our great cultivators have been enabled to study their natural habits, they are grown in a state of perfection which it is doubtful if they ever attain in a state of nature. In the tropical forests they establish themselves upon the branches, and either vegetate in the midst of decayed vegetable and animal matter, or cling to the naked branches by their long, succulent, grasping roots, while they draw their food from the humid sultry atmosphere; for it appears they attach themselves alike to rocks and stones in moist places, where they grow luxuriantly.

On the confines of the Orchidaceous plants we find the family APOSTASIACEÆ, herbaceous perennials of the Indian woods, in many respects resembling the Orchids; differing from them chiefly in having a three-celled fruit, and a style altogether separated from the stamens for the greater part of its length; the PHILYDRACEÆ are grassy-looking herbaceous plants of Australia and Asia, exhibiting the great spathetic bracts of the Musaceæ, with the habit of Sedges.

The XYRIDACEÆ are herbaceous fibrous-rooted plants, with sword-shaped radical leaves dilating and equitant at the base, the flowers having imbricated scaly heads, calyx glumaceous, three-leaved, corolla petaloid and coloured, petals three and stamens six. These plants join to the habit of Sedges and other glumaceous plants, some approach to the peculiarities of Liliaceous plants. The *Juncaceæ*, or Rushes, partake of the characteristics of the *Xyrids*, approaching the grasses in the glumaceous character of the calyx and corolla, and Xyrids in that of their calyx and bracts. They are herbaceous plants, with tufted or creeping roots and tapering stem, often with a distinct pith.

The ORONTIACEÆ are herbaceous plants with broad, entire, or deeply-divided, sometimes sword-shaped, leaves. They occupy woodland stations chiefly within the tropics of both hemispheres, but are found also in colder regions, one of them, *Symplocarus*, being

common in the swamps of the United States; another, *Calla palustris*, in the deep muddy marshes of South Lapland, in 64° north.

The beautiful creations which constitute the Liliales have been cultivated and admired for ages. In Fig. 363 the petaloid corolla of the Lily is represented; and in Fig. 364 the group of Lilies represented will give a general idea of the habit of the type of the LILIALES.

The protecting envelope of the flower of the Lily (Fig. 363) is composed of six folioles or petals, which as a whole form the delicate white and odorous flowers of the Lily. Of these six folioles, the three exterior ones constitute a petal-shaped calyx; while the three inner ones, which are placed alternately with those of the outer

Fig. 363.—Petaloid Corolla of the Lily.

Fig. 364.

circle, and differ slightly in form and colour from them, constitute the corolla.

The Andræcæum is composed of six stamens, disposed in two verticilles with white filaments, elongate two-celled anthers attached to their backs, filled with a yellowish pollen, and opening longitudinally.

The pistil of the LILY is composed of three carpels, as may be ascertained by an examination of the constituent parts. These

three carpels are united, constituting one whorl; thus appearing as one organ standing in the centre of the flower, *o* being the

Fig. 365.—Group of White Lilies.

ovary, *s* the style, and *st* the stigma. The ovary, which is free or superior, presents three swelling sides externally, with three

inner cells, the walls of which correspond to the three deep external grooves formed by three capillary leaves united together by their contiguous edges. Numerous ovules are inserted in two series at the central angle of the cells. The style, which is thickest at the summit, is crowned by a three-lobed stigma. The matured fruit forms a capsule which opens of itself—not by deglutination, but by an opening in the dorsal suture of each cell; that is to say, the dechiscence is *loculicidal.* The seed presents an embryo in a direct axis in fleshy albumen.

The Lily is a deep-rooted perennial plant, with bulbous root. The bulb is scaly (Fig. 366); the stem of the large proportion of those which are natives of cold countries perish after ripening their leaves, flowers, and fruit. The leaves generally are lanceolate in their lower parts and linear above; the last ovate as well as lanceolate. The flowers form a cluster, white, yellowish, or reddish, brown or spotted, according to their variety.

Fig 366 —Bulb of the Lily.

The Liliaceous plants are generally large and showy, especially in those with annual stems, as the Lily itself, the Fritillaria, the Odorous Hyacinth, the Star of Bethlehem, the Hemerocalleæ, and the Tulip, which combines all that is rich and beautiful in colour and form. But there are Liliales of arborescent size and stem, as the Dragon-Tree (*Dracæna Draco*), in which the flower contracts, so that the largest trees have the smallest flowers.

The *Tulipeæ,* which Dr. Lindley considers the type of the order, are bulb-producing annual stems, bearing cup-shaped flowers remarkable for their colours, without spathes, and the anthers lightly attached to a stiff filament. This division of the order includes the Lilies, Fritillarias, Dog's

Tooth Violet. One of these, the *Lilium Chalcidonicum*, covers the plains of Syria with its scarlet flowers.

The *Hemerocalleæ*, or Day Lilies, have the calyx and corolla joined together, so as to form a tube of considerable length. The fragrant Tube Rose and Agapanthus belong to this division, and the Aloes resemble them in almost all their parts, except the thick succulent foliage.

The *Asperageæ* includes the Common Asparagus and the Lily of the Valley, *Dracæna* and *Ruscus*. The geographical limits of the order are as wide as its differences. Aloes abound in the southern parts of Africa. The Dragon-trees, the most gigantic of the order, attain their greatest size in the Canaries, where the Dragon-tree of Orotava (Plate VI.) is described as being between seventy and seventy-five feet high and forty-six feet in circumference at the base. All travellers to Teneriffe visit this gigantic Lily, which is, according to tradition, an object of adoration to the Guanchos, who are the primitive people of these islands. It is probably long anterior to historic times. At the conquest of Teneriffe by the Spaniards, it was already as large and as hollow as it is to-day.

"This gigantic tree," says Von Humboldt in his "Pictures of Nature," "grows in the garden of M. Franchi in the little villa of Orotava, called Taora, one of the most beautiful spots in the civilised world. In 1799, when we ascended the peak of Teneriffe, we found that this enormous vegetable was forty-five feet in circumference a little above the root. Sir George Staunton asserts that at the height of ten feet the tree is twelve feet in diameter. Tradition reports that this tree was an object of veneration to the Guanchos, as the Elm of Ephesus was to the ancient Greeks; and that in 1402, when Bethencourt visited the island, it was as large and as hollow as it is now. The most gigantic Dragon-tree that I have seen in the Canary Isles was sixteen feet in diameter; it seemed to enjoy an eternal youth, and still bore flowers and fruits.

"When Bethencourt, the French adventurer, conquered the Fortunate Isles in the sixteenth century, the Dragon-tree of Orotava was found to be as sacred in the estimation of the natives as was the Olive of the Athenian Acropolis in the eyes of its inhabitants. It is described as being of the same colossal dimensions as it has attained in our day. In the Torrid Zone a forest of Cæsalpina

and of Hymenæa is perhaps a monument one thousand years old; and remembering that the Dragon-tree of Orotava is of very slow growth—that its appearance now differs very slightly from the same tree described four hundred years ago—we may conclude that it is extremely aged. It is, without contradiction, with the *Baobab*, perhaps the most ancient inhabitant of our planet.

"It is very singular," he adds, "that the Dragon-tree has been cultivated from very remote times in the Canaries, in the islands of Madeira and Porto Santo, although it must have come from the East Indies, a fact which contradicts the assertion of those who would represent the Guanchos as an Atlantic race, entirely isolated and as having no connection with the Asiatic or African races."

The *Dracænæ* are evergreens, either of a shrubby or arboraceous nature, having long slender stems, often columner after the manner of the palms; their trunks present marks, cicatures produced by fallen leaves; they are soft and cellular at the centre, with a circle of stringy fibres towards the exterior. The leaves are simple, but in some of the species, instead of the veins running parallel with the midrib, they are perpendicular to it, after the character of the leaves of *Musaceæ*. They are usually clustered together at the end of the branches, like the inflorescence, which is terminal. The structure of the stem and leaves is interesting, as the fossil genera *Clathraria* and *Sternbergia* have been compared to *Dracænæ*, the former by Adolphe Brongniart, and the latter by Dr. Lindley.

The Alismales, including the Butomaceæ, Alismaceæ, and Tancagenaceæ, conclude the important class of Endogens in Dr Lindley's arrangement of the Vegetable Kingdom. The Butomaceæ are made interesting to us by the Flowering Rush, perhaps the handsomest flowering plant of indigenous birth.

The Liliales are distinguished by their complete flowers, free from the ovary, by their sepals and petals being equally coloured, by their delicate and well-developed flowers, and by their abundance of albumen. In the *Gilliesaceæ* they approach the *Alismaceæ*. The true Lilies have some slight resemblance to the Rushes. The wood of some of them, as *Yucca* and *Dracæna*, arranges itself in circles, indicating a tendency to approach the great class of Exogens.

The LILIACEÆ, the typical family of the group, are herbaceous plants, shrubs, or trees, with bulbs, tubers, rhizomes or fibrous roots. The leaves are narrow and sword-shaped, with parallel veins, only a very small number expanding into broad blades with diverging veins. The flowers are perfect—conspicuous, in spikes, heads, and clusters, umbels or panicles generally large and showy.

They are all water-plants, with erect and leafless stems, narrow leaves dilated at the base, and pedicelled perfect flowers, forming a terminal umbel, subtended by three membranous bracts, a perianth with six divisions, the three outer petals slightly coloured and distinct from the sepals, which are larger and more highly coloured. Stamens nine, with free ovary, consisting of six carpels more or less united by the ventral suture. The style is short, terminating in a lateral stigma.

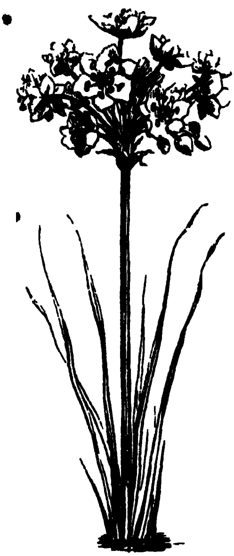


Fig. 367.
Flowering Rush.

The *Alismaceæ* are aquatic plants, floating on ponds or growing in swampy places, distinguished from other orders of the same group by the sepals and petals being perfectly distinct from each other both in colour and position. The root is usually a perennial creeping rhizome. The flowers form umbels, racemes, or panicles. The leaves expand into a broad blade with parallel veins. The Water Plantains, as they are sometimes called, are known by their numerous carpels, and imperfect floral envelope. They are chiefly natives of Northern regions, but several Sagittarias are found in the tropics of both hemispheres.

CLASS V.—DICTYOGENS.

Among the Monocotyledons of Jussieu and Endogens of later botanists there is a small class of plants which are referable to Endogens in the structure of the embryo, but which more resemble Exogens in a broad net-veined foliage, which usually disarticulates with the stem, their small green flowers nearly

resembling those of *Menisperms*. This class Dr. Lindley considers to be distinct from Endogens on the one hand, and Exogens on the other. He calls them Dictyogens, from the netted structure of their foliage. They are distinguished as having leaves net-veined, deciduous; wood of the stem, when perennial, arranged in a circle round the central pith, the wood of the root being exogenous, that is, without concentric circles, and the leaves falling off the stem by a clean separation, as in Exogens.

Flowers bisexual, with adhering perianth, carpels consolidated, and several seeded, including the Yam of tropical countries.	LXVI. Dioscoreaceæ.
Flowers hexaperdal, bisexual, carpels several, placenta axial, including the diuretic Sarsaparilla of South America.	LXVII. Smilaceæ.
Flowers three, six-petaled, unisexual, carpels several, placenta perietal.	LXVIII. Phylesiaceæ.
Flowers tripetalous, bisexual, carpels several, axial placenta . . .	LXXI. Trilliaceæ.
Flowers bisexual, carpels solitary, simple, many-seeded, and basal placenta.	LXXII. Roxburghia

The DICTYOGENEÆ, from δικτοσα, "a net," and γινεσθαι, "to be," are a small division of plants, partaking of Endogens on the one hand, and Exogens on the other. The foliage is broad, net-veined, and branching; but simple, and of regular outline; the leaves disarticulating with the stem, and in some cases the small green flowers are very nearly the same as some of the *Menispermum* among Exogens. "For these reasons," says Dr. Lindley, "I have endeavoured to show that they ought to be regarded as a transition class, partaking somewhat of the nature of Endogens and also of that of Exogens. In the rhizome of the whole genus" (of sarsaparilla), he adds, "the wood is disposed in a compact circle, below a cortical integument, and surrounding a true pith; in *Smilax aspera* the woody matter is disposed in the form of a cylinder, enclosing a centre of soft cellular matter, the vessels of the cylinder having an evident tendency to arrange themselves in lines forming rays from the centre."

The DIOSCOREACEÆ are distinguished by their diœcious flowers, superior calyx and corolla, six stamens and three-celled ovary. They are all twining shrubs. The various species of *Dioscorea* and *Testudinaria* produce edible farinaceous tubers, but *Thamus* exhibits a dangerous acridity.

In the order *Dioscoreaceæ* we find the tropical esculent, the Yams, a genus of fleshy-rooted diœcious plants, with annual twining stems, broad alternate leaves with netted arrangement

of veins, bearing small green flowers in clusters; the calyx and corolla, taken together, consist of six small equal segments, or female flowers, which stand at the top of the ovary—the male flowers having six stamens, the females three styles. The seed-vessel is a thin compressed three-winged capsule, containing one or two membranous seeds.

The tubers of *D. alatea* are oblong, brown externally, white inside. Natives of the West Indies, they grow freely in the East Indies. They perish if left in the ground after the first year, having first produced the young tuber which is to replace them. Besides the tuber, they throw out fibrous roots, which spring chiefly from about the union of the stem with the tuber, spreading in all directions. The stems are furnished with four crested leafy wings, twining round trees and bushes, often bearing prickles near the ground.

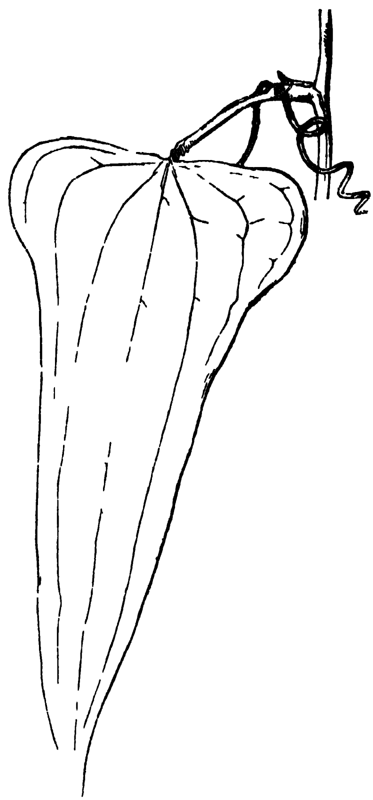


Fig. 368 —Leaf and stalk of Smilax

The SMILACEÆ, a small order, consist of the *Smilax*, or Sarsaparilla, and *Ripogonum*; the former evergreen climbing shrubs (Fig. 368), a few of which are found in temperate, but the majority in the warmer regions of both hemispheres. They are fibrous or tuberous rooted plants, with stems often prickly, leaves alternate and petiolate, and stipulate between the petioles, and sessile flowers on a globular receptacle. The botanical name *Smilax* occurs in Greek authors, as Theophrastus and Dioscorides; but applied to several kinds of plants, as the yew. The only known species belonging to the present order was *Smilax aspera*, a

species of *Phaseolus*, or Convolvulus, of South Europe, celebrated for its medicinal properties. The different kinds of *Sarza*, or Sarsaparilla, are now drawn from natives of South America. Though the genera are limited, the species are numerous and important.

The PHYLESIACEÆ are chiefly twining, sometimes upright shrubs, with large and showy flowers, about which little is known. The TRILLIACEÆ are simple stemmed herbaceous plants, with tubers or rhizomes, resembling the Sarsaparillas in many respects. The ROXBURGHIACEÆ are twining shrubs, with tuberous roots, large, showy, and somewhat fœtid flowers, having reticulated and coriaceous leaves. There is but one genus and few species, all natives of the hotter parts of India.

CLASS VI.—GYMNOGENS.

An important class of plants, which mark a transition between the simpler forms of vegetation and plants of more complicated structure. They differ from most vasculars by the vessels of their wood having large perforations or discs; but their habits of growth are essentially exogenous, while their tissues are peculiar to themselves. Their organs are exogenous; the stem consists of concentric zones; a vascular system, with spiral vessels and a central pith, while they resemble Acrogens in their growth, which is continued by a terminal bud.

The wood is thus: youngest at the circumference, and concentric. They have two or more cotyledons, with naked seeds.

They are without style or stigma, but so constructed that the pollen falls immediately upon the ovules—a peculiarity analogous to what occurs among the class of reptiles in the animal kingdom.

Have a simple continuous stem, leaves parallel, veined, and pinnate; scales of the cone antheriferous, including the Cycads, Zamias, and Macrozameas.	LXXIII. Cycadeaceæ.
Stem branched, continuous leaves, simple, and acerose, females in cones, including the Pines, Abies, Junipers, and Cypresses.	LXXIV. Pinaceæ.
Stem repeatedly branched, continuous, leaves simple, sometimes fork-veined. Females, solitary anthers, two celled, opening longitudinally, including the Yews of Europe, the Dacridiums of New Zealand, the Podocarps of the Cape.	LXXV. Taxaceæ.
Stem repeatedly branched, jointed leaves, simple net-veined anthers, one-celled, opening by pores, including two genera, the *Gnetum* or Joint-firs, and *Ephedra*, natives respectively of temperate Europe and America, and of the hottest parts of India.	LXXVI. Gnetaceæ.

The GYMNOGENS, from γυμνος, "naked," and γινεσθαι, "to be," and

from the ovules being uncovered, and the pollen communicated directly to the ovules without the intervention of stigma, style, or ovary. The plants comprehended in this great class agree with the flowering plants in having their vascular tissues complete, approaching the higher forms of vegetation in the Joint-Firs. The *Gnetaceæ* combine the habit of growth of Chloranthus with the structure of their own class. With the Ferns and Club-mosses, some of the Cycadeaceæ agree in habit in the peculiar gyrate vernation of the leaves, and in the less perfect structure of the spiral vessels and reproductive organs, some of them having the gyrate vernation of the leaves of Ferns, along with the inflorescence peculiar to Coniferæ, and their habit of growth, although essentially the same as Exogens, yet resembling the growth of Acrogens in the lengthening of the terminal bud. In their mode of increase Gymnogens differ from other Exogens only by having a kind of tissue peculiar to themselves, in consequence of which their wood presents large apparent perforations or disks, as in the Coniferæ.

The CYCADEACEÆ are characterised by the cylindrical and unbranched growth of the trunk, and the development of one terminal bud, and by its diœcious flowers, the male flower generally growing in cones composed of peltate scales. In the *Zamias*, the female flowers are disposed in the same manner; in the *Cycas* they are placed on the toothings of abortive leaves occupying the centre of the terminal bud. The leaves are pinnate, having some resemblance to those of Ferns and Palms; their wood is arranged in numerous consecutive circles in *Cycas*, and also in a confused manner round the central pith, thus partaking of the peculiarities both of the Exogens and Endogens. Mr. Robert Brown demonstrated the similarity of conformation between the flowers of *Cycas* and Coniferæ, and Adolphe Brongniart determined the resemblance between them in the structure of the vessels of their wood, thus confirming the proximity of the former to Ferns; their relation to the Coniferæ is established by both being cotyledonous, and both their seeds having naked ovules, "constructed," says Dr. Lindley, "in a similar remarkable manner, and borne in both cases not upon an ordinary axis of growth, but upon the margin or face of metamorphosed leaves; the same peculiar form of

inflorescence, the same kind of male flowers, the same constant separation of the sexes, and a like imperfect formation of spiral vessels; and both agree in having the vessels of their wood marked with circular disks; a character which, if not confined to them, is uncommon elsewhere." They are all natives of the tropics, or of temperate America, and the eastern part of the colony of the Cape of Good Hope, where they form thickets along the Caffre frontier.

The PINACEÆ are noble trees or evergreen shrubs, with a branching trunk abounding in resin. The leaves are alternate, elongated, linear, and lanceolate, acicular, or pointed, sometimes fasciculated in two, three, or five bundles, each of them being a little branch with very short axis; when thus fasciculated the primordial leaf to which they are then axillary is membranous and enwraps them like a sheath, as in *Pinus strobus*, in Fig. 369. The flowers are monœcious, that is, they bear male and female flowers upon the same stem. The male flowers are composed of a floral axis, along which are inserted a considerable number of stamens having a short filament, and an anther which opens from without in two longitudinal clefts; this anther is surmounted by a dilated connective like a tongue. The female flowers are disposed in a catkin, and are each composed of an ovarium destitute of style or stigma; spreading in the manner of scales, and bearing on its internal surface two suspended ovules, *orthotropal*, or in a straight line with its axis. Fig. 370 represents the male flower with an enlarged view of the anther; Fig. 371, the female flower with capillary scales, showing on the right hand a pair of inverted ovules. When these flowers have ripened, the scales become hard, ligneous, and thickened at the summit into a club-like shape; they now form the composite fruit we call a Cone, which has given a name to the family in various botanical systems. The cone is represented in Fig. 372. It is formed of scale-shaped ovaries, now enlarged and hardened, and sometimes of bracts also, which are occasionally obliterated, and sometimes extend beyond the scales in the form of a lobed appendage. These scales finally drop from the tree, become disintegrated and scattered, and buried in the

Fig. 369

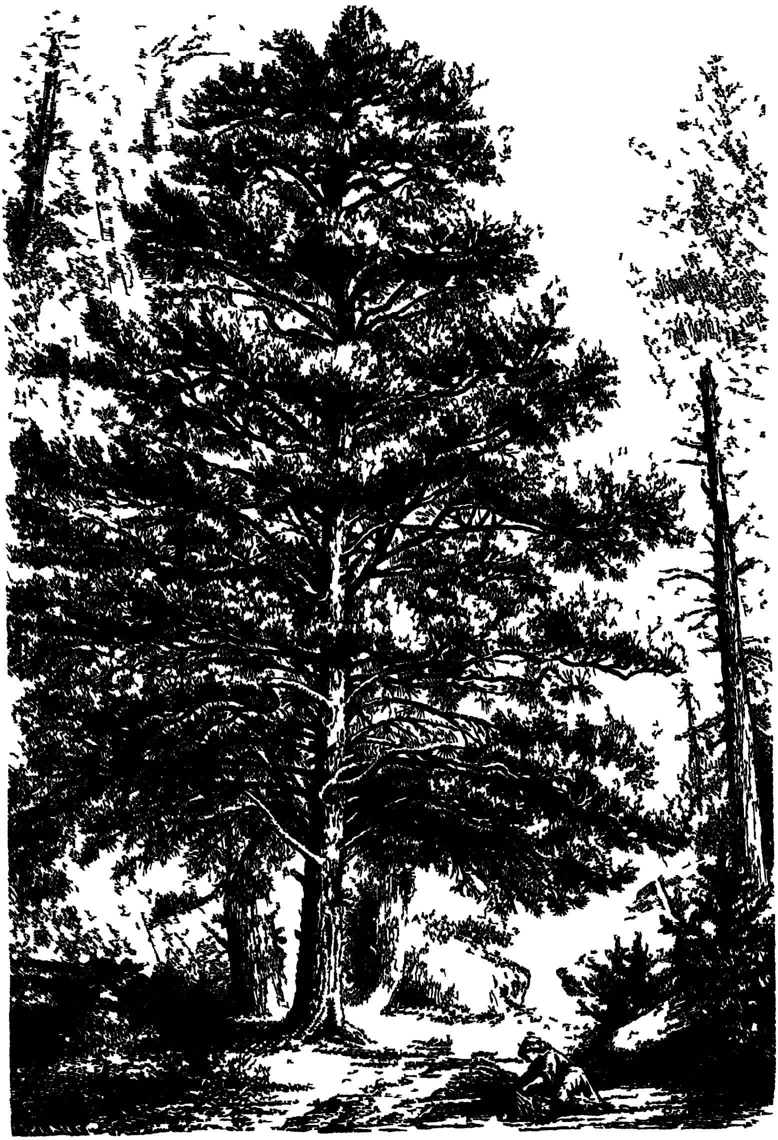


Plate VII.—*Pinus Sylvestris*

soil, thus completing the end of their existence, namely, the propagation of their species.

Fig 370 – Male Flower of Pinus sylvestris

Fig 372 —Fruit of the Pine.

Fig 371 —Female Flower of Pinus sylvestris.

The Pinaceæ or Conifers are resinous, mostly evergreen and hard-leaved trees or shrubs, all but universally diffused over the globe. Gigantic in size, rapid in growth, noble in aspect, and robust in constitution, these trees form a considerable portion of the woods and plantations in cultivated countries, as well as of primeval forests in all temperate countries. In Europe, Siberia, China, and North America the species are abundant; the timber trees being exceedingly valuable in commerce, in which Deal, Fir, Pine, and Cedar are well-known products, while their resins yield oil of turpentine, Canadian balsam, Burgundy pitch, all equally well known. The common Larch yields Venetian turpentine; liquid storax is produced from a species of Pine, spruce beer is made from branches of the Hemlock spruce, and Savin: a well-known irritant is made from the Juniper.

Among the double-leaved Pines worthy of consideration, we may mention the *Pinus sylvestris* represented in Plate VII.—this is the Scotch Pine of erect and upright trunk, two short glaucous

leaves, the most hardy and valuable of all the Pines; the Maritime Pine; the Corsican Pine (*P. larcico*), a noble tree spread over the mountains of Corsica, Greece, and Turkey, celebrated for its rapid growth, and excellent timber. The Pines or Conifera are usually divided into three sub-orders. I. ABIETINEÆ, comprehending the Firs, Pines, Spruce and Larch tribes, all of which bear cones with one or two inverted ovules at the base of each scale of the cone; pollen oval, and curved. II. CUPRESSINÆ, or Cypress tribe, bearing an indurated globular cone called a gabbulus, with connected scaly ovules, erect, and spheroidal pollen, including the Cypresses and Junipers. III. TAXINEÆ, or Yew tribe, of which Dr. Lindley forms an order (his seventy-fifth). The Taxineæ bear for fruit a species of drupe, with solitary oval in the centre.

In the first of these divisions the Firs differ from the Pines in their cones, which are furnished with thinish scales slightly rounded at the apex, and without the club-like shape, and in their scattered distichous leaves; such is *Abies pectinata*, the Silver Fir, from which Strasburg turpentine is extracted; while Burgundy pitch and oil of turpentine are obtained by incision from *Pinus sylvestris*, which is also a valuable timber for building purposes. The Larches (*Larix*) again differ from the Firs in this: their leaves spring from a bundle of scaly buds, and become at once scattered or solitary in consequence of the lengthening of the leaves; the imbrication of the scales of the cone is very loose; the leaves of the Larch are persistent and evergreen during winter. In the male flowers of the Larch, as well as the Cedars and Spruces, each anther is formed of converted scales analogous to the indurated capillary scale of the females, and therefore each catkin consists of a number of naked male flowers collected about a common axis.

The Larch of Europe attains a height of from ninety to a hundred feet; the wood is of a reddish colour, its tissues closer and considerably harder than that of the Fir-trees, and a very pure turpentine, which is used in arts and medicine, oozes out from incisions made in its bark.

The CUPRESSINÆ, the type of which the Cedars may be considered, are distinguished from the Larches by their leaves being persistent during several years after the elongation of the bud, and by the scales of the cone being more closely imbricated. The Cedars of

Lebanon (Plate IV.) are trees having an aspect full of grandeur, spreading their vast horizontal arms thirty or forty feet from the stem, which rises forty or fifty feet above the soil. Upon the back of Mount Atlas, in the North of Africa, and in the temperate countries of Asia, the Cedar forms immense forests of a most majestic and imposing aspect. There is indeed no nobler object than the Cedar. "The Lebanon," say the Arabian poets, "bears winter on his head, spring on his shoulders, and autumn in his bosom, while summer sleeps at his feet;" and in confirmation of the truth of the sentiment a few venerable Cedars still remain; they form a beautiful grove on the line of route from Baalbec to the coast. They are large and massy, rearing their heads to an enormous height, and spreading their branches afar; but they have a strangely wild aspect, travellers say, as if wrestling with some invisible person bent on their destruction while life is still strong in them; but they are gradually disappearing. In 1575 there were found twenty-four standing in a circle; in 1630 Fermanil counted twenty-two; there are now seven standing near each other, and a few more almost in a line with them.

"Standing in their strength erect,
Defying the battled storm."—SOUTHEY.

The other plants of which we have spoken belong to a vast section of the Pinaceæ, designated under the name of *Abietineæ* and *Cupressinæ*, and presenting a great number of essential common characters. The trees of which we have now to speak, namely, the Thuja and the Juniper, differ in many respects from the tribe of the Abietineæ. The Thujas, or *Arbor vitas*, are monœcious plants; their male flowers are composed of a filiform floral axis, upon which are inserted numerous stamens, which may be likened to nails with which old-fashioned doors are sometimes studded, supporting under their heads four unilocular one-celled anthers. The female flowers are disposed in catkins, each scale of which bears two erect orthotropal ovules. These soon become fleshy and consolidated, but when at maturity, they dry up, and in doing so detach themselves and separate, thus setting the pollen grains free to escape. Thujas are evergreen trees with flattened branches resulting from very small imbricated and compact leaves. In the

Arbor vitas the pistil and stamen are in separate flowers on the same tree ; the male catkins are terminal and solitary; the pollen of each flower is included in four cases attached to the inner face of the scale towards the base. They are trees or shrubs, natives of Asia, Africa, and America.

The Cypress very much resembles the Thujas; they are essentially distinguished from them by their leaves being mere scales, their cones

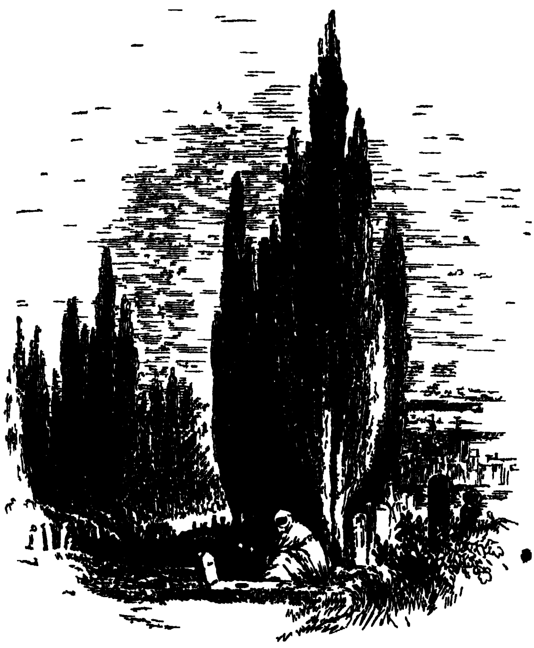


Fig. 373.—Group of Cypress Trees

mere bracts, by the seeds being small, angular, and several to a bract, and by the number of seeds which are pressed into the base of each scale. In the Cypress (*Cupressus sempervirens*) the branches leave the parent stem at a very acute angle, giving to the tree its very peculiar physiognomy.

The common Juniper (*Juniperus communis*) is a native shrub, with long, narrow, sharp-pointed leaves, in verticulates of three, patutous, rigid, and almost prickly edged: it is monœcious. The

scales of the female catkin, which are not more than six in number, generally three, are succulent; they present this curious fact, that they become fleshy, and constitute by their scales, representing carpels collected in a spiral round a common axis, a sort of spherical berry, black or blue, containing ordinarily three bony seeds called botanically *Galbuli*. In some countries in the North of Europe these fruits are subjected to fermentation, and a spirit is obtained, known under the name of Gin or Hollands, sometimes Geneva, from the French name *Genevre*. The Virginian Juniper, also called Red Cedar, furnishes a light odorous wood, with which the cylinders are made in which we enclose the lead of our pencils. The savin, of stimulating, diuretic, and uterine powers, is extracted from *J. Sabina*.

The TAXACEÆ, or Yews, are trees with continuous unarticulated branches; their leaves very close together, entirely veinless, almost distichous, linear, and sharp pointed, of a deep green colour: flowers diœcious. The male flowers are composed of an elongated floral axis, upon the whole length of which are inserted a variable number of stamens, which may be said to resemble studs or nails, the connective being the head. On the lower side of this connective, six or eight bilocular anthers are disposed circularly round the *filament*. The female flowers are solitary and surrounded with imbricated bracts; they consist of a sessile ovule at the centre of a highly developed disc. When arrived at maturity this disc becomes fleshy, and forms a little cupulate of a lively red, which loosely envelops the seeds. The tree then appears as if covered with little cherries. These plants occur in milder climates all over the world, and in elevated situations in the tropics. They are resinous, like Conifers, and possess excellent medicinal qualities. They include Salisburia, a tree of great beauty and elegance.

The GNETACEÆ, or Joint Firs, are small trees or sarmentose twiggy shrubs of the temperate parts of Asia, South America, and Europe, with opposite leaves or clustered branches, and thickened separable articulations. "This little family," says Blume, "constitutes a part of that natural class of vegetables in which the fertilisation of the ovules takes place immediately, without the aid of style or stigma, through the foramen of the ovule itself. From

the Pinaceæ and Cicadeaceæ this order differs in the greater perfection of its reproductive organs, while the ovules are covered with a pericarpal integument, opening at the summit."

In the Gymnosperms, which connect the lower with higher forms of organisation, the transition is very distinctly marked. In Cycads the stem is simple and cylindrical, the departure from its terminal mode of development being exceptional and accidental, while the Conifers exhibit a constant tendency to a rapid evolution of leaf-buds in every axil. An increasing value in their products is also observable. The Cycads, for instance, yield a mucilaginous juice, mixed with starch, from which common articles of food are prepared. At the Cape of Good Hope the fruit of the various species of Encephalartos are called "Caffre bread," and a kind of arrowroot is prepared in Mexico from the seeds of *Dion edule*. In Japan a sago is procured from the cellular substance occupying the stem of *Cycas revoluta*, and also from *Cycas circinalis* in the Moluccas. Other species are also utilised in the countries of which they are natives. The Pines and Fir-trees are chiefly valuable for their timber, and the Yews and their allies are valuable for their resinous products, and also for timber, which is unsurpassed for elasticity and durability; and in Amboyna the seeds of *Gnetum Gnemon* are eaten roasted, boiled, or fried, and the green leaves are a favourite vegetable eaten and cooked as spinach.

Class VII.—Exogens.

The Dicotyledons of Jussieu, and the Exogens of more recent botanists, include the more highly organised plants, which are moreover endowed with proportionate vitality, for "while a century or two terminates the existence of most endogenous trees, some existing Exogens were monarchs of the forests at the beginning of the Christian era." As already explained, Exogens add their new wood to the outside between the bark and wood of last year's growth.

The class of Exogens numbers over 66,000. Their germination is *exorhizal*, the embryo with two or more cotyledonous leaves having a network of veins; the trunk formed of woody bundles of

fibre, composed of dotted woody tubes alone; arranged round a central pith, forming either in eccentric rings, or in a homogeneous mass, but always having medullary plates radiating from the centre to the circumference, which are reproduced on the circumference of the trunk. Genera, 6,191; species, 66,225.

All botanists are agreed that the organs of reproduction may be expected to furnish the best characters for classification after those necessary for nutrition. Linnæus was of this opinion, and he made them to a considerable extent the basis of his system, but he mainly relied upon their number. The importance of the stamens and pistil did not escape the observation of Jussieu, who separated from all other Exogens those having the stamens in one flower and the pistil in another, and he called them Diclinous. By this means he brought together a collection of natural orders corresponding with the monœcious and diœcious plants of Linnæus. But, in carrying out his system, he excluded a vast number of truly diclinous plants. Some of these anomalies have been corrected by recent observers, and Dr. Lindley has divided the whole of the vast class of Exogens into (1) Diclinous, (2) Hypogynous, (3) Perigynous, and (4) Epigynous Exogens.

Sub-Class I.—Diclinous Exogens.

Having Male and Female, without any tendency to Bisexual Flowers.

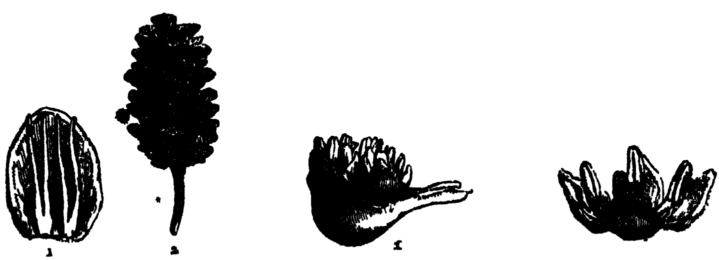
Having flowers forming catkins, without or with only one floral envelope; carpels superior, embryo small, little or no albumen; ovary one-celled, ovules, one or two ascending, radicle ascending. This includes the She-oak of Australia.	LXXVII. Casuarinaceæ.
Ovary one celled, ovules one, pendulous, radicle superior, including the Maples, the Alder, Birch, plane trees, &c.	LXXVIII. Betulaceæ.
Ovary two celled, with numerous winged seeds, including the Balsam yielding trees with many-seeded capsules, and the several species of Liquidambar.	LXXIX. Attingiaceæ.
Ovary one-celled, with numerous cottony seeds growing at the base of a two-valved capsule, as in Willows and Poplars.	LXXX. Salicaceæ.
Ovary one-celled, with a single erect seed and superior radicle. The fragrant Gales of America, the Cape, and India are aromatic shrubs or trees, utilised in various ways in tropical countries. In Sweden, Myrica Gale is a substitute for hops.	LXXXI. Myricaceæ.
Ovary one-celled, with a single ascending ovule, an inferior radicle, and flowers sometimes bisexual. The beautiful and fragrant Oleastro grows extensively over the Northern Hemisphere, down to the Equator.	LXXXII. Olæagnaceæ.

The Amentales are declinous Exogens with unisexual flowers, amentaceous inflorescence, and incomplete calyx. These characters form an obvious bond of union in this important natural group; and a brief description of the Betulaceæ, or Birches, and Salicaceæ, or Willows, are the most familiar examples we can

offer. They are trees or shrubs, with simple alternate leaves nearly orbicular in shape, with primary veins running nearly straight from the midrib to the margin; stamens usually distinct; ovary superior and two-celled; fruit membranous, indehiscent and one-celled; seed pendulous. The Birch-tree, *Betula alba*, is monœcious, with alternate leaves, ovate and peteolate, accuminate and dentate or doubly dentate, green and glossy above, of a pale glabrous green below. Their straight upright stems, smooth silvery bark, long, round, slender, flexible, and pendulous branches, render the Birch a graceful ornament in the landscape.

The Birch is in flower in the month of April, when the white silvery bark produces the happiest effects contrasted with the deeper and more sombre tints which the trunk of the Elms and Oaks present.

The Alder, *Alnus glutinosa*, has stalked simple stipulate leaves. Flowers in male and female catkins, the male flowerets loose and cylindrical, usually in threes on the pedicle of the scale; stamens,



Bract bearing two female flowers. Ripe Catkin. Bract bearing three flowers of the Alder. Isolated male flower.

Fig. 374.

three or four inserted at the base of the divisions. Female flowerets in dense ovate catkins, two together on roundish sessile fleshy scales, with four smaller ones at their base, each with a small ovary, and two one-seeded cells. The glutinous leaves, red sap, and wingless fruit distinguish the only British species of Alnus from the Birches.

The Alder (Plate VIII.) inhabits the margin of rivers, and marshy places in woods; its round nearly orbicular leaves are of a sober green on the upper surface, and a pale glabrous green beneath, but slightly glossy when young. This tree, like the Birch, is

Plate VIII —Alder Tree (*Betula alba*).

Osier beds are generally found where they can be under water the greater part of the year; while the Sallows, as *S. caprea,* rather affect dry woods and hedges; others, as *S. lanata,* are beautiful mountain shrubs, the fertile catkins of which are sometimes found a span long in Glen Dole and Glen Callater.

Willows abound in temperate regions, but decrease sensibly in number towards the South of Europe and in Algeria. They serve to consolidate the borders of water and rivers. The Willow furnishes means for the basket-maker's work.

The White Willow (Fig. 375) is the most important of its species, on account of the large dimensions which it acquires: it is very productive in Osiers and Pollards.

The Weeping Willow (*Salix Babylonica*), of which we have already given a representation at page 66, is particularly remarkable for the length, flexibility, and graceful drooping habit of its branches,

Fig. 375.—Male catkin of the Willow.

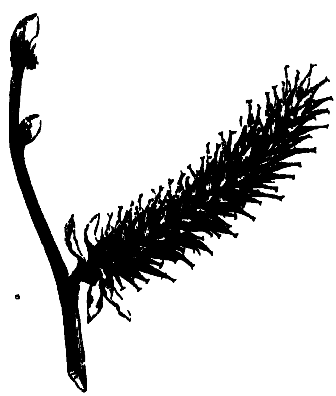


Fig 376.—Female catkin of the Willow.

which give it an appearance of melancholy grace. Its country is unknown; we only possess the female specimen.

The *Salix reticulata,* Wrinkled Willow, is a very small shrub of from one to two feet high, which grows in the Alps, the Pyrenees, and on the Welsh and Scottish mountains.

The herbaceous Willow is also a very small shrub, with stem creeping under ground and emitting branches almost completely herba-

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ceous; it grows in the High Alps and the Pyrenees, in Mount Doré in Auvergne, and also in the Grampians. Willows are diœcious; their flowers are in catkins, and solitary, with an axil to each scale of the catkin. They have no envelopes. Figs. 375 and 376

Fig. 377.—Male Flowers of Salix alba.

Fig. 378.—Female Flower of Salix alba.

represent the male and female catkins of the Willow; 377 and 378 show the isolated flowers.

The Poplars (*Populus*) are nearly allied to the Willows, and in the flowers they are only distinguished from them by the greater number of stamens, which are inserted on the internal face of a kind of cup.

The Black Poplar (*Populus nigra*) is among the larger of these trees, commonly known as the Swiss Poplar. The White Poplar (*Populus alba*), a fine tree with ample cyme, is furnished with leaves remarkable for their extreme whiteness underneath, especially upon the most elevated shoots. Fig. 379 represents this species.

The Aspen (*Populus tremula*) is the only real forest-tree of this genus; it is of middle height, with leaves which are very mobile in consequence of their length; they are compressed vertically, which leads to the horizontal tremulous motion which distinguishes the tree and procured its name.

The Pyramidal Poplar, originally from the Caucasus and Persia, was imported into Italy and France about the year 1749; it is remarkable for its erect branches which spring from nearly the base of the trunk, and altogether form a long, straight, pyramidal cyme: only the male plant of this species is known.

Among the Amentales the Casuarineaceæ are for the most

Fig. 379.—White Poplar.

part Australian trees, or scrubby bushes of little value to man. The BETULACEÆ are natives of Europe, Northern Asia, and North America, where the bushes exist on the limits of eternal snow; they are of little value as timber. The sap of the common Birch, *B. alba*, is obtained in spring, in North America, by tapping the trees; and an agreeable sparkling wine is obtained from it by fermentation: sugar is also made from *B. nigra*, and the bark and the leaves and catkins are used by dyers and tanners.

The ALTINGIACEÆ are tropical plants of India, North America, and the Levant, storax being yielded by several species of *Liquidambar*, and others abounding with benzoic acid. The SALICACEÆ, as we have seen, are chiefly valuable to the basket maker, by whom most of the numerous species are woven into baskets and other useful and ornamental products.

The MYRICACEÆ are leafy shrubs, or small trees, having resinous glands and dots; natives of the tem-

perate parts of America, the Cape of Good Hope, and India. The fragrant Gales are shrubs or trees of considerable size. The ELÆAGNACEÆ, or Oleasters, are trees or shrubs of the northern hemisphere down to the equator. *Elæagnus hortensis* bears a fruit about the size of an olive, which is brought to market in Persia. The red drupes of *E. conferta* and several others are eaten in India. The only species growing wild in Britain is *Hippophae rhamnoïdes*, a spiny shrub with diœcious flowers, and small, round, orange-coloured acid berries; it grows on the cliffs near the sea; its fruit becomes rather a pleasant preserve when sufficiently sweetened. *E. augustifolia* is one of our most fragrant garden plants, filling the air with its perfume, while the dull yellow flowers which exhale the delicious fragrance attract little attention.

Having scattered flowers with one-flowering envelope single superior carpels, and large embryo lying in a small quantity of albumen, with superior radicle, twin ovules, straight albuminous embryo, two-lobed anthers, and vertical fissures.	LXXXIII. Stilaginaceæ.
Radicle superior, ovule erect and solitary, embryo straight, albuminous, juice limpid, stipules small and flat in the Nettles.	LXXXIV. Urticaceæ.
Radicle inferior, embryo without albumen, plumule many-leaved, large	LXXXV. Ceratophyllaceæ.
Herbaceous, rough stemmed, watery plants, with solitary suspended ovules, hooked embryo, without albumen, and superior radicle. Hemp and the Hop belong to the order.	LXXXVI. Cannabinaceæ.
Radicle superior, ovules solitary, suspended, embryo hooked, albuminous, juice milky. The Mulberry and Fig belong to the order.	LXXXVII. Moraceæ.
Trees or shrubs, abounding in milky juice, radicle superior, large convolute stipules, ovules solitary, erect or suspended, straight embryo without albumen. Includes the Bread-fruits. The Upas tree of Java belongs to the family.	LXXXVIII. Artocarpaceæ
Deciduous trees or shrubs with sheathing stipules, round heads of unisexual flowers in separate catkins, limpid juice, inferior radicle, albuminous, embryo long, no calyx, and minute plumule. The PLANES are noble timber-trees of temperate intertropical climates, resembling the Sycamore, sometimes called the Plane tree with us.	LXXXIX. Platanaceæ.

The URTICALS differ from the preceding group chiefly in the absence of catkins, and in some cases the presence of albumen. In the typical order Urticaceæ, containing the Nettles, Figs, the Hop, the Mulberry, the Hemp, and the celebrated Upas tree, the species are widely diffused over every part of the world,—in the frozen North, and in the hottest tropical countries. The order, as formerly constituted, was nearly synonymous with the group, but it is now limited to a few genera characterised by the causticity of the limpid juice they yield. The stinging effects of the Nettles, *Urtica dioca* and *U. ureus*, will be familiar to most

readers; but these are not to be compared for an instant with some of the East Indian species. Listen, for instance, to De la Tour's description of the effects of the sting of *U. crenulata.* "One of the leaves" he says, "slightly touched the first three fingers of my left hand; at the time I only perceived a slight pricking, to which I paid no attention. This was at seven in the morning. The pain continued to increase. In an hour it had become intolerable; it seemed as if some one was rubbing my hand with a red-hot iron. Still there was no remarkable appearance, neither swelling, nor pustule, nor inflammation. The pain spread rapidly along the arm as far as the arm-pit. I was then seized with frequent sneezings, and with a copious running at the nose. About noon I experienced a painful contraction of the back of the jaws, which made me fear an attack of tetanus. I went to bed, hoping that repose would alleviate my suffering; but it did not abate; on the contrary, it continued nearly the whole of the following night: but I lost the contraction of the jaws about seven in the evening. The next day the pain left me. I continued to suffer for two days, and the pain returned when I put my hand into water; and I did not finally lose it for nine days."

Fig. 380.—Male Flower of Cannabissativa.

The CANNABINACEÆ, represented by the Hemp (*Cannabis sativa*), (Figs. 380 and 381), originally came from Persia, but has since become acclimatised to all parts of Europe. It is well known that

the free libre, one of the elements of its bark, makes this plant eminently precious to man.

The Hemp is a diœcious herbaceous annual, with opposed lower leaves. The upper leaves are often alternated and deeply intersected, with from five to seven acuminate or linear lanceolated segments, strongly dentated, rough, and of a pale green colour underneath; two lateral stipules accompany them. The male flowers are disposed in bunches, and are composed of a calyx with five divisions and five stamens, with bilocular anthers opening from within by two longitudinal clefts, opposite to them. The female flowers are disposed in axillary leafy glomerules, and present a calyx formed by two divisions and a pistil composed of an upper ovarium, surmounted by a short style, with very long filiform stigmata. The unilocular ovarium encloses a single ovule. The fruit is an Achenium; the seed, without albumen, encloses an embryo folded upon itself.

Fig. 381.—Female Flower of Cannabis sativa.

It is from another species of the Hemp (*Cannabis Indica*) that the Indians make the intoxicating liquor commonly known under the name of *Haschich.* The Orientals make a deplorable abuse of its intoxicating powers.

The Hop (*Humulus lupulus*), a perennial plant, with voluble stems and opposite lobated leaves in the shape of a Palm, belongs to the same family as the Hemp. It is found wild in Europe in hedges and upon the banks of rivers. The Hop is cultivated in England, Germany, France, and Belgium. The female flowers are

disposed in compact ovoid ears, forming cones when at maturity by the development of their sepales and bracts. The fruit or achenes are covered with a granulous powder of a greenish or golden yellow colour; they are very odorous, and contain an active principle to which chemists have given the name of *Lupulin*. The cones of the Hop are used in the manufacture of beer; they are tonic, and slightly narcotic.

The MORACEÆ are trees and shrubs, sometimes climbing plants mostly yielding a milky juice. The Fig (*Ficus*) and the Mulberry (*Morus*) are natives of warm countries, where they form vast forests, the thick trunks and strong boughs of the Fig with its large head being conspicuous. Travellers speak of the noble aspect of the Wild Fig, of their gigantic dimensions, and the thick delightful shade cast by their leafy heads. Fraser, speaking of their habits at Moreton Bay, says, "I observed several species of *Ficus*, upwards of one hundred and fifty feet high, enclosing immense Iron-bark trees, on which the seeds of those Fig-trees had been originally deposited by birds. Here they had vegetated and thrown out their parasitical and rapacious roots, which adhering close to the bark of the Iron-tree, had followed the course of the stem downwards to the earth, where, once arrived, their progress and growth is truly astonishing. The roots increase rapidly in number, envelop the iron-bark, and send out at the same time such gigantic branches, that it is not unusual to see the original tree, at the height of seventy or eighty feet, peeping through the Fig as if *it* were a parasite on the real intruder." But the Pagoda-tree (*Ficus Indicus*) excells all others in its magnitude, one tree being capable of giving shelter to a regiment of cavalry. This tree is a native of India and the islands of the Indian Ocean, reaching its greatest perfection in the villages on the skirts of the Circar mountains. The branches cover a vast extent of ground, dropping their roots here and there, which as they reach the ground rapidly increase in size till they become as large as the parent trunk. Roxburgh says he has seen such trees full five hundred yards round the circumference of the branches, and a hundred feet high, the principal trunk being twenty-five feet up to the first branches, and eight or nine feet in diameter.

All the species of *Ficus* abound in a milky juice containing

caoutchouc, the best known quality of that valuable product being obtained from *F. elastica.* The leaves of *F. Indica* are ovate, heart-shaped, three-ribbed, and entire; when young, downy on both sides, smooth when more matured, and from five to six inches long, and three to four broad, having a broad, smooth, greasy-looking gland on the under side of the leaf-stalk at the top. The figs grow in pairs from the axils of the leaves; they are downy, and about the size and colour of a ripe cherry at maturity.

F. elastica, the Indian Caoutchouc tree, will be known to most readers; it is now common in all the hothouses in the country, and numbers of fine plants may be seen in the Palm House at Kew. It has large glossy leaves, thick, oval, and pointed; small axillary, uneatable fruit of the size of an olive, and long reddish terminal buds composed of rolled-up stipulæ. In its native fields it grows to the size of the European Sycamore, chiefly among decomposed rocks and vegetable matter over the declivities of mountains, growing with great rapidity as a young tree, attaining the height of five-and-twenty feet in four years, and with a trunk a foot in diameter. The milk is extracted by making incisions through the bark to the wood, at the distance of a foot from each other, all round the tree, and up to the top. After one course of tapping the tree requires to rest a fortnight, when the process may be repeated. When the liquid is exposed to the air it becomes a firm and elastic substance, fifty ounces of pure milky juice yielding about fifteen ounces of clean, washed caoutchouc. The Pippul, or Sacred Fig of India, *F. religiosa,* is known by its rootless branches and heart-shaped foliage, with long attenuated points. It is common in every part of India, where it is planted for the sake of its grateful shade. It is held in superstitious veneration by the Hindus, because, according to tradition, Vishnu was born under its shade. The long pointed leaf has a wavy edge and long slender and flat footstalks, which produces a tremulous motion in the air, like that produced by the Aspen-tree (*Populus tremula*). Silk-worms seem to prefer this leaf to the Mulberry, and they are used by the natives of Arabia for tanning leather. The Sycamore Fig (*F. sycamorus*) is a large tree which grows in Egypt round the villages near the coast, and gives grateful shelter to the villagers under its widely-spreading head. The leaves are broad, ovate, and angular, and the fruit is

produced in clustered racemes upon the trunk and old limbs. The figs are sweet and delicate.

The Common Fig (*Ficus carica*) was originally found in the eastern and western regions of the Mediterranean. It was introduced and has been cultivated in Europe from the most ancient times. They are frequently found growing almost spontaneously in the South of France. Generally growing as a shrub, the Fig can also be found as a tree of four or five feet in height. The leaves vary in form on the same plant. They generally present from three to seven unequal and obtuse lobes. The flowers are unisexual, and placed upon the internal walls of a common receptacle, pierced at the vertex with a small orifice, that protects a large number of imbricated bracts. The male flowers have a calyx composed of three sepals, with three stamens opposed to them, and bilocular anthers that open from within by two longitudinal clefts. The female flowers have a calyx formed of five sepals, and a pistil composed of an upper ovarium, surmounted by a style, that divides itself into two stigmated branches. This ovarium is unilocular, and encloses only one ovule. The fruit of the botanists (that generally known to the world) is a thick, fleshy, and succulent receptacle, that constitutes the Fig. The fruit we say, then, is an achenium; and the grain contains under these integuments a fleshy albumen, in which is a recurving embryo.

The ARTOCARPACEÆ, or Bread-fruit tribes, abound in the warmer parts of the world, and many of them are natives of the tropics. They bear so close a resemblance to the Nettle tribes (*Urtica*), that botanists find it difficult to separate them by any well-defined characteristics. Their chief characters are a very imperfectly-formed calyx, no corolla, leaves with inconspicuous stipules, a rough foliage, and an acrid milky juice which often contains caoutchouc; the flowers are collected round the head, and the ovules suspended singly from the upper part of the ovarium. Their milk, which is always acrid, acquires properties in Upas tree (*Antiaris*) which render them intensely poisonous; that substance must, therefore, be entirely absent before the fruit can be eaten with safety. This applies even to the Common Fig, which in its immature state, when milky, is acrid and unwholesome; but as the milk disappears, its place is supplied by sugar, and the fruit

becomes wholesome and delicious. The same is probably the case with all the Bread-fruits.

The Bread-fruit would seem to be an inverted Fig. The trees have stems of considerable size, large rough leaves, stipules like the fig, monœcious flowers, the stamen-bearing ones disposed in long club-shaped spikes, the pistil-bearing ones in round heads, which afterwards become the solid receptacle round which the fruit ripens, in contradistinction to the Fig, in which the receptacle is internal and fleshy. *Artocarpus incisa*, the Bread of the South-Sea Islands, is green, and equal in size to the larger melons. One variety produces the fruit free from spines on the surface or seeds internally; others split into deep lobes, or are covered all over with the sharp-pointed fleshy tops of the calyx. The nuts when roasted are said to taste like chestnuts; but it is principally for the fleshy receptacle that it is valued, and this when roasted becomes soft, tender, and white, and not unlike the crumb of bread when eaten new.

The UPAS-TREE (*Antiaris toxicaria*), the half-fabulous poison tree of Java, was said to be a large tree growing in the midst of a desert produced by its own pestiferous qualities, and causing death to every other plant and animal which came under its influence. To approach the tree for the purpose of wounding its stem and carrying off its juice, was said to be the task of criminals condemned to death. There is a measure of truth in the fable. There is the Upas-tree in Java, and its juice, taken internally, is speedy death to any animal; and there is a tract of land where neither plant nor animal can exist; but the two circumstances have no connection. The poisoned tract is the crater of a volcano, which emits carbonic acid gas continually—a spot where not even the Upas-tree can grow. The Upas-tree is one of the *Artocarpaceæ*, which abounds in milky juice, and this juice, as we have said, is like many of its congeners, a deadly poison when mingled with the blood.

The PLANES (*Platanus*) are exogenous trees, or shrubs, with palmate deciduous leaves, toothed and stipulate, unisexual naked flowers, in globose catkins, the barren flowers with single stamens mixed with scales. The fertile flowers with one-celled ovary, thick and awl-shaped style. The Oriental Plane (*P. orientalis*)

is a tree of noble growth, in many respects resembling the Sycamore, with its large palmate leaves. Its wood is fine-grained and hard, and when old it acquires dark veins, somewhat resembling Walnut-tree. *P. occidentalis* ranges from Mexico to Canada.

The Plane-tree is one of the largest trees of temperate regions. Pliny relates that in his time there existed a celebrated Plane-tree in Lycia, the hollow trunk of which formed a kind of grotto, measuring 90 feet in circumference. Its branching arms resembled a little forest; the branches composing it covered an immense space of ground. The hollow of the trunk was carpeted with moss, which gave it still more the appearance of a natural grotto. Licinius Mercianus, the Roman governor of Lycia, gave a feast in this grotto to eighteen guests. Pliny mentions another Plane-tree which the Emperor Caligula found in the neighbourhood of Velitria, the branches of which were so disposed as to form a grotto of natural verdure, in which the Emperor dined with fifteen persons. Although the Emperor occupied a part of the tree alone, the guests were all quite at their ease, and the slaves were able to perform their offices with perfect convenience.

At Caphyas, in Arcadia, eight hundred years after the Trojan War, an old Plane-tree was shown bearing the name of Menelaus carved on its bark. It was then said that this prince planted it himself before his departure for the seat of war. It is also related of the chief of men, Agamemnon, that he planted a Plane-tree at Delphos, which was seen many centuries after the death of the hero. These assertions are probably fabulous; but what makes recitals of this kind somewhat credible, is the fact that, at the present time, Plane-trees of an age and dimensions quite extraordinary still exist in the East. De Candolle, in his "Physiologie Végétale," records the statement of a modern traveller in the East, to the effect, that in the valley of Bussekdere, three leagues from Constantinople, there exists a Plane-tree 100 feet in height, the trunk of which was 175 feet in circumference. The trunk presented an excavation 80 feet in circumference. Its shadow extended over 500 square feet. Plate X. is a representation of the Plane-tree of Bujukdere, a celebrated tree all over the East, although the documents which would determine its exact age are wanting.

The Urtical and the Euphorbal groups, ranging from the seventy-third to the ninety-fourth natural order in Dr. Lindley's system, form the most remarkable tribes in the whole vegetable world. We have briefly traced the history of the Urticaceæ, and their congeners, which include the Bread-fruit-tree, the Hemp-plant, the Mulberry, Fig, and the Plane-trees; the Euphorbias include the Crowberries, and the strangely-shaped Pitcher-plants. We have seen side by side with these plants, so useful to man, the caustic Stinging Nettle of our own climate, the deadly Upas-tree, and many other plants distinguished by their dangerous properties at some stage of their existence.

The EUPHORBALS are chiefly distinguishable from the Urtical tribes by their compound consolidated pistil, which exhibits a more complex organisation than the other. They are diclinous Exogens, with scattered flowers, having two floral envelopes, consolidated carpels, axial placentæ, and large embryo, in many with abundant albumen, but sometimes without. The Euphorbias number no less than two thousand species, three-eighths of which are natives of intertropical America, sometimes forming trees, bushes, and even weeds; occasionally they are deformed, leafless, succulent plants, resembling the Indian Figs in appearance, but altogether different from them in properties; many of them are medicinal, as *Ricinus communis*, the Castor Oil-plant, and the Crotons.

As their name indicates, they are acrid Exogens, with definite suspended ovules, anatropal, with scattered flowers and leaves, and three-parting fruit. The order contains a vast number of species, some of them highly poisonous, others, like the Castor Oil-plant, with fine medicinal properties.	XC. Euphorbiaceæ.
The Scepads are Euphorbial Exogens, with unisexual amentaceous flowers, definite anatropal ovules, suspended, superior radicle coriaceous leaves, and membranous stipules forming the scales of the buds. They are natives of Indian forests.	XCI. Scepaceæ.
The Starworts are aquatic Euphorbials, with definite suspended anatropal ovules, superior radicle; flowers unisexual, axillary, solitary, and minute, destitute of calyx, and albuminous.	XCII. Callitrichaceæ.
The Crowberries are small acrid shrubs with heath-like leaves, without stipules, and minute flowers in their axils; they are Arctic plants slightly acrid.	XCIII. Empetraceæ.
The Pitcher-plants are herbaceous, or half shrubby plants, the stem bearing both leaves and fruit; their leaves assume a most singular development, which gives rise to hollow organs—the pitcher.	XCIV. Nepenthaceæ.

The Pitcher-plants (*Nepenthes*) are placed here for the excellent reason that no place more suitable could be found for them. With certain insignificant resemblances to the tribe,

they possess other characteristics which are without parallel. The dilated foliaceous petiole, with its pitcher-shaped termination, and its articulated lid-like lamina, are among the curiosities of the vegetable world. (Fig. 382.)

Fig 382 —Pitcher Plants.

Nepenthes phyllamphora. The petiole P *a p* leaves the stem at A, and spreads into a flat leafy member, P; it then contracts into a wiry petiole, as *a*, which performs a revolution, and again

expands into a hollow pitcher-like organ, *p*. The lid of the pitcher is the lamina of the leaf, which is articulated with the pitcher. The pitcher is supposed to be formed by the two margins of a flattened petiole, technically a phyllode. "The petiole," says Mr. Dresser, "leaves the stem in the form of a flattened leaf, which, after expanding laterally, again contracts, and is continued in the form of a long tendril-like organ, the summit of which becomes hollowed and dilated, and thus forms the body of the pitcher upon the extremity of which the lamina appears as the lid of the vegetable jug."

QUERNALS.

A sub-division of diclinous Exogens, which comprehends the Oak, the Beech, the Walnut-trees, and some others of the temperate zone. Their unisexual flowers are aments, or catkins, with monochlamydous envelope, an inferior fruit, with Almond-shaped embryo without albumen.

Includes our most important fruit-trees and shrubs. Exogens with two or more cells in the ovary, pendulous or peltate ovules; they are readily distinguishable by their catkins and leaves, their apetalous rudimentary calyx, fruit enclosed in a husk or cup, and nut containing one cell and one or two seeds. The order includes the Oaks, the Hazel, the Beech, and the Chestnuts, the Lithocarpus or Stone Oak of Java, among others the *Fagus procera*, said to exceed *Araucaria* in size.	XCV. Corylaceæ.
Oak-like Exogens, having a one-celled ovary and one solitary erect ovule, are trees with a watery or resinous juice; they are chiefly American, a few Indian, and the common Walnut, *Juglans*, the nut of Jove, is a native of Persia. The Hickory (*Carya*) of America produces an edible fruit and valuable timber. The *Engelhartdias* are very numerous.	XCVI. Juglandaceæ.

The HAZEL (*Corylus avellana*) is a monœcious shrub, of about twelve feet high. It is common in woods, thickets and copses, and is often planted in belts near hedges, or other fences. The branches are erect, slender, and flexible, with simple alternate leaves, doubly dentated, sometimes superficially lobed, accompanied by two caducous stipules. The male flowers are disposed in pendent catkins of from one to three, disposed at the extremity of the branches, or upon the short lateral shoots. These catkins begin to turn green towards the end of autumn, before the fall of the leaf, and they flourish to the end of winter, when the development of the new leaves takes place. The male flowers, contained between two little scales, have five stamens, with unilocular anthers opening from without. The female flowers are composed of a

calyx, with very small denticulated limbs, and a lower ovarium with two cells, each containing a suspended anatropal ovule. This ovarium is surmounted by two long styles of a lively red. At the period of fructification the involucrum has undergone great development; it has become foliaceous, a little fleshy, and slightly bell-shaped at its base, opening at the summit and containing a fruit, or nut, which is an achenium, in consequence of the abortion of one of the cells, and of the ovule, which it encloses. The seed, with slight membranous shell, contains an embryo destitute of albumen, under a slight integument: cotyledonous, smooth on the surface of one side, and convex on the other.

The common Yoke Elm, or Hornbeam (*Carpensis betulus*), when allowed to attain its natural dimensions, is a graceful tree, rising to the height of twelve to thirty feet, with a slightly smooth and ashy grey bark, and somewhat resembling the Beech in its appearance. The male flowers are disposed in cylindrical catkins, the imbricated scales of which directly protect from six to twenty stamens, with short bifurcated filaments and unilocular anthers barbed at the summit. The female flowers are disposed in clusters, the exterior with caducous bracts, of which each bear two unifloral involucrum, presenting an appearance very analagous to those of the Hazel-tree. The fruit has a foliaceous, veined, reticulated cupule, with three lobes, the middle one of which is much larger than the other two. The most important principle of the wood of the Yoke Elm is in its caloric power. It is an excellent firewood. It is much used in the fabrication of certain tools, and in parts of machines which are subjected to much friction, and where great durabiltiy is necessary; but it is coarse, and in consequence of the larger size of its medullary processes it is unfitted for cabinet work. The Hornbeam is an indigenous British tree, very common in copses, and is frequently pollarded by the farmer. When checked and stunted in this way it retains its withered leaves all the winter, and is useful where winter shelter is required. The wood was anciently used as yokes for cattle, hence its popular and scientific name from the Celtic word *Car*, wood, and *pinda*, head.

The Oaks (*Quercus*) are monœcious trees with simple alternate leaves, each having two caducous stipules. The male flowers are disposed in filiform catkins, slender, interrupted, and pendent

(Fig. 383). Each flower presents a calyx with six or eight free unequal divisions, the margin being bordered by long slender pro-

Fig 383 —Male Catkin of the Oak.

cesses, and an equal number of opposed stamens, with bilocular anthers, which open from without by two longitudinal clefts. The

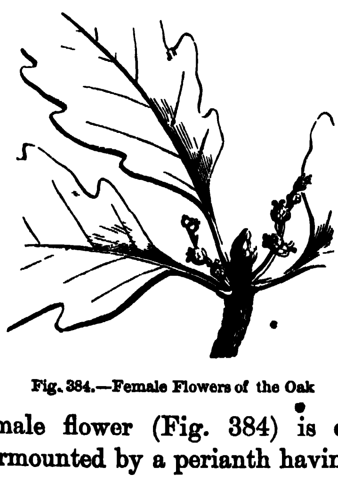


Fig. 384.—Female Flowers of the Oak

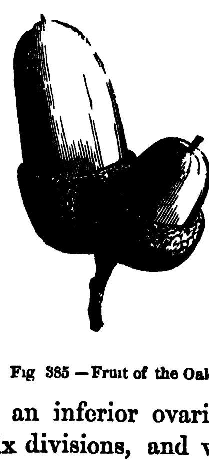


Fig 385 —Fruit of the Oak

female flower (Fig. 384) is composed of an inferior ovarium, surmounted by a perianth having three or six divisions, and with

a short style, which is divided in three stigmatic branches, added to which it is surrounded by a sort of little cup, or cupulla, formed by a fold of the peduncle, upon which a large number of small imbricated bracts are inserted. The ovarium is three-celled, each having two anatropal ovules. At maturity, two of these three cells, with their contents, are abortive. The fruit, designated under the name of an Acorn (Fig. 385), is of an ovoid or oblong shape, umbilicated at its summit with a cartilagnous and shiny pericarp, becoming from this shape unilocular and monospermous. Under its covering this seed presents an embryo destitute of albumen, the cotyledons of which are convex on the outside, and flat on the inside; they are also fleshy and farinaceous. The fruit is enveloped at its base by the indurated and ligneous cupulla of which we have spoken.

The Oaks belong almost exclusively to the northern hemisphere, where they inhabit the temperate regions, or the high mountains of equatorial countries. The species which they include, unlike Roses, are scarcely known in a wild state in the southern hemisphere, their southern limits being the islands of the Indian Archipelago, whence they spread westward along the Himalayan range until they reach Europe. The Oaks are the most majestic trees of our forests, with robust hardy trunks, and powerful, far-spreading branches. It will be convenient to divide them into Forest Oaks, or *Roburs*, *Ilexes*, and *Clubbed Oaks*.

The common Oak, *Q. pedunculata*, is the true British Oak, which is alone suitable for ship-building on account of its durability and hardness; but it is probably more influenced by the soil on which it grows; and for the Oak, the soil of Sussex seems to surpass any other; the Sussex Oak is also recognised as the best kind employed. This is *Q. pedunculata*, which is recognised by the very short stalks of the leaves, while the acorns are borne on long stalks.

The Sessile-cupped Oak, *Q. sessiflora*, sometimes called the English Oak, is found all over England, but is more abundant in the West, and constitutes the greater part of the Oak in North Wales. It is of more rapid growth than the last, and attains much larger dimensions.

Quercus sessiflora, represented in Plate XII., is a tree with a

Plate XII.—The Oak (*Quercus sessiliflora*)

frame of variable size, with petiolate, oblong, almost oval, sinuated leaves, with a fructifying peduncle much shorter than the petioles; the fruit arrives at maturity the same year with the flowers which are to produce their successors.

Quercus Ilex is an Evergreen Oak, native of the European continent, of some 50 to 60 feet in height; the leaves are shiny above, grey or whitish and tomentose on the lower surface; the fruits are sessile, or borne by the short, downy, or rather hairy peduncle, with tubulous, scaly, cotonous cupulla. They grow in arid places, and are common in the South of France. The acorns are sweet and eatable. The wood is very combustible, and much used in France as fuel; besides which, it is largely employed in naval construction, carpenter's and cabinet work.

The Cork-tree (*Quercus suber*), of which we have already spoken in the chapter on Bark, is closely allied to the Evergreen Oaks; its leaves are persistent till the end of the second and even the third year. It is, as already stated, the corticle, or bark, largely developed, which produces the substance known under the name of cork. It grows upon mountains of slight elevation, a little removed from the basin of the Mediterranean. Limited to some parts of the South of France and to Spain, the Cork Oak is the predominant inhabitant of the forests of Algeria, where it constitutes woods of great extent, occasionally mixed, however, with other denizens of the forest.

The Kermes Oak (*Quercus coccifera*) is a tufty bush, of from 7 to 12 feet high, with small, oblong, cordate, dentate, thorny, persistent leaves of a smooth green; common in dry, sandy, and stony places in the regions of the Mediterranean. It is upon this little Oak that the cochineal, a hemipteral insect, lives, from which the beautiful scarlet colour was obtained before the introduction and employment of the cochineal of the Cactus (*Cochinillifera* of Nopal) into Europe.

Club-shaped Oaks are distinguished by their thin and deeply dentated leaves, the loose, narrow scale of their cup, and their long deciduous stipules.

The *Quercus cerris*, rather rare, but widely disseminated in France, is remarkable for the scales of its cupulla, which are linear, recurved on the outside, and gyrose on their upper part. In this species

the female flowers remain stationary during one year of their appearance, and do not complete their evolutions till the autumn of the second year.

The Spanish Oak (*Q. Hispanica*) bears its branches erect; leaves nearly evergreen, lanceolate, and acute, and finely serrated; dark green on the upper side, glaucus green on the under surface. Bark thickly cortical, and top shaped with shaggy, prickly, spreading scales. This tree grows in Spain and Algeria, and is found in some of our nurseries under several synonyms.

Besides these species there is the Austrian Oak (*Q. Austriaca*) found in Hungary and Lower Austria; the prickly capped Valonia (*Q. Aigelops*), which grows in the Morea, valuable for its acorns, which are largely imported for tanning purposes; and various Oaks, the produce of the mountains intervening between India and Asia Minor. Of the species which Dr. Royle found in the Himalayas, most of them are too tender for acclimatisation with us, but some of them are beautiful trees.

The American Oaks are numerous in species, but their timber is by no means of the same value as their European congeners. The White Oak (*Q. alba*) produces sweet acorns and excellent timber, some specimens in the American forest attaining the height of seventy or eighty feet. The Chestnut-leaved Oak (*Q. prinus*) is cultivated in all the nurseries and under eight or ten synonyms. It is a handsome tree, with broad bright-green foliage, but its timber is light and porous. The Black Oak (*Q. tinctoria*) is a native of the Carolinas, Georgia, and Pennsylvania, where it attains a great size, with large, handsome ovoid leaves, downy beneath, which become dull, red, or yellow in the autumn. The tree is more appreciated for its colouring properties than for its timber, the latter being coarse-grained; but its inner bark abounds in a yellow dye of great brilliancy, known as Quercitron, which is much sought after. The Live Oak (*Q. virens*) is a valuable timber tree, which grows in the Southern States of the Union, growing on the shores of the creeks and bays. It is a heavy, compact, fine-grained wood, with coriaceous, oblong leaves, obtuse at the base, clothed with starry down beneath; acorns oblong, and said to be sweet tasted.

Many species of Oak are found on the high lands of Mexico and

the adjoining States, growing at a height of five or six thousand feet above the sea. Some of them, as the Iron Wood Oak (*Q. sideraxyla*) and the Large-leaved Oak (*Q. macrophylla*), trees either yielding valuable timber, or of great beauty. The large-leaved oak is, perhaps, the finest oak in the world; its leaves, which are downy beneath, tapering at the point, and heart-shaped at the base, being from 12 and 18 inches long, and broad in proportion; and its acorns are large as French walnuts.

The Beech (*Fagus sylvatica*) is one of our best known and most important forest-trees. It attains great dimensions, sometimes rising to the height of 100 feet with us, and even 120 feet in more favoured climates; its smooth, strong stem, which becomes ashy grey by exposure to the weather, rises round and straight through its foliage, remaining visible to its first branch, so that a Beech wood presents a clear vista, their thick leafy heads preventing brushwood from growing under them. It is sometimes free from branches to the height of 60 feet. Its leaves, petiolate, ovate or oblong, are generally pointed or acuminate, loosely dentated, waving, and coriaceous, with prominent ciliated veins: silky at the edges; they are alternate, and accompanied by two brownish stipules; they are shining and thin, changing in the autumn to a brownish russet. The flowers, which are unisexular, appear at the same time as the leaves. The male flowers are disposed in long, pendent, globular catkins; with long peduncles; and very small pendent, caducous scales. The female flowers are enveloped, to the number of two or three, in a common two-lobed prickly involucre, covered exteriorly with a number of filaments; the fruit is the Beech-nut. The seed contains an embryo without albumen, the cotyledons of which are irregularly folded up inside, and strictly coherent. The oil obtained from this seed is both eatable and a good lamp oil.

Among the Beeches many handsome varieties, well adapted for ornamental purposes, from their variously coloured foliage, have originated. *S. purpurea*, the Purple Beech, has the young buds and shoots of a rich rose colour. In the Copper Beech (*S. cuprea*) they are pale copper colour; in *S. variegatus* they are white and red, interspersed with streaks of red and purple. In some, the leaves

are curled up. In others, as *S. pendulata,* the branches are pendulous, or weeping.

The smooth thin bark of the Beech is apt to develop the knobs called embryo-buds, or abortive branches, which are sometimes used by cabinet makers. Its branches are numerous, and its foliage dense and shady, so that the Bird's-nest Orchis is often found under its shade, parasitical on its roots; among which also, but not upon them, the common Morel flourishes in the Beech forests of France and Germany.

The Chestnut (*Castanea vulgaris*) is a tree of rapid vegetation, and endowed with great longevity. It attains a height of 20 to 100 feet, occasionally presenting an enormous circumference. Its leaves are large, petiolate, oblong, acutely lanceolate, deeply dentate, coriaceous, smooth and shining, with prominent secondary parallel nerves, accompanied by two caducous stipules.

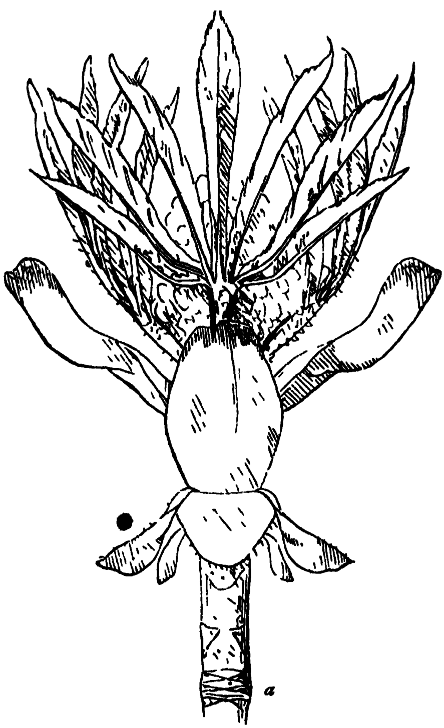


Fig. 386.—Inflorescence bud of the Horse-Chestnut.

The flowers are unisexual, and appear after the leaves. The male flowers are very small catkins, each flower being composed of five or six divisions, with as many or more stamens, having bilocular anthers opening from without. The female flowers are, to the number of five or six, enveloped in a common four-lobed involucrum consolidated externally with numerous unequal linear bracteoles. Each female flower consists of a lower ovarium, surmounted by a calycinal limb, having five to eight lobes,

and an equal number of styles. It encloses a like number of cells containing two anatropal ovules. When arrived at maturity, which is in the month of September or October, the involucrum is thick and coriaceous, charged on the outside with a soft prickly fasciculated envelope, and enclosing from one to five unilocular fruits by abortion, known under the name of Chestnuts. The pericarp is coriaceous, fibrous, and hairy on its external surface. The seed contains an embryo without albumen, under a membraneous covering; the cotyledons are voluminous, and plicated with fissures of greater or less depth, and, as is said, farinaceous. The Chestnut is the principal produce obtained from this useful tree; this fruit forms the principal food of the poor populations of the central flats of France, and of the valleys of the Alps.

Improved by culture, the Chestnut-tree has given place to the variety called *Marronier* by the French cultivators, of which several varieties are known. They yield the large Chestnuts which sometimes come into our markets.

The native country of the Chestnut is not very clearly ascertained; it is probably Asiatic however—at least, the common name is Turkish, and is derived from their custom of grinding up the nuts and mixing it with the food of broken-winded horses, and probably of others also when favourites.

The famous Chestnut-tree of Mount Etna, said in Sicily to be the "Chestnut of a Hundred Horses" (*Castagno de cento Cavalli*), is reported to be 170 feet in circumference. Jean Houel gives the history and dimensions of this gigantic tree. "We departed," he says, "from Ace-Reale in order to visit the Chestnut called of 'the hundred horses.' We passed through Saint Alfro and Piraino, where these trees are common, and where we found some superb old chestnuts. They grow very well in this part of Etna, and they are cultivated with great care. Night not having yet come, we went at once to see the famous Chestnut which was the object of our journey. Its size is so much beyond all others that we find it impossible to express the sensation we experienced on first seeing it. Having examined it carefully, I proceeded to sketch it from nature. I continued my sketch the next day, finishing it on the spot according to my custom, and I can now say that it is a faithful portrait, having demonstrated to my own satisfaction that the tree was 160 feet in circumference, and

having heard its history related by the *savants* of the hamlet. (Plate XI.) This tree is called the 'Chestnut of a Hundred Horses' in consequence of the vast extent of ground it covers. They tell me that Jean of Aragon, while journeying from Spain to Naples, stopped in Sicily and visited Mount Etna, accompanied by all the noblesse of Catania on horseback. A storm came on, and the Queen and her *cortége* took shelter under this tree, whose vast foliage served to protect her and all these cavaliers from the rain. It is true that out of the hamlet the tradition of the Queen's visit is looked upon as fabulous; but however that may be, the tree itself seems very capable of doing the office assigned to it.

"This tree with its vaunted diameter is entirely hollow. It is supported chiefly by its bark, having lost its interior entirely by age; but is not the less crowned with verdure. The people of the country have erected a house here, with a sort of furnace for drying the chestnuts and other fruits which they wish to preserve. They are even so indifferent to the preservation of this wonderful natural curiosity that they do not hesitate to cut off branches to burn in the furnace.

"Some persons think that this mass of vegetation is formed of many trees which have united their trunks; but a careful examination disposes of this notion. They are deceived. All the parts which have been destroyed by time or the hand of man have evidently belonged to a single trunk. I have measured them carefully, and found the one trunk as I have said, 160 feet in circumference."

We should be inclined to adopt the opinion here hinted, that this monster tree was the union of several, but M. Houel's sketch and description seem conclusive; and his opinion is further confirmed by the fact that many chestnuts in the neighbourhood of Mount Etna are 12 yards in diameter, while one actually measures 83 feet.

Now, what age can be assigned to the Mount Etna Chesnut? It is difficult to say. If we are to suppose that each year its concentric layers have only been a line in thickness, this venerable tree would be not less than three thousand six hundred and forty years old.

At Neuve Calle, on the Geneva Lake, there exists another Chesnut of gigantic proportions.

Plate XIII —The Walnut Tree (*Juglans*)

The JUGLANDACEÆ, whose prevailing qualities are acridity and aroma, includes the common Walnut (*Juglans regia*). (Plate XIII.) It is a large tree, with whitish bark, more or less fissured according to its age. It has a cylindrical stem, rising to a considerable height without branches; the branches are large and spreading, forming an ample and rotund head. The leaves are of a dull greenish colour. The Walnut is indigenous to the Caucasus, Persia, and India. This tree only prospers and is abundantly fruitful when it is completely isolated. The leaves are alternate, smooth, and coriaceous; they are composed of seven or eight acutely ovoid leaflets, superficially sinuate, and are monœcious. The flowers, male and female, are disposed in catkins; but in the female catkins the flowers are less numerous. The male catkins have loosely imbricated scales, are pendent, cylindrical, very caducous, and placed at the axil of the leaves which have fallen the preceding year. At the axil of each scale a flower may be observed, composed of a perianth with six divisions, and a variable number of stamens ranging from eighteen to thirty-six, the anthers of which are two-celled, opening from without by two longitudinal clefts. The female flowers are in clusters of drooping catkins, of from one to four, born on the summit of a young shoot produced the same year, presenting a very short, scarcely dentate, exterior envelope, and an interior envelope with four divisions. A short style rises from the centre of the flower, which soon divides itself into two stigmatic scaly glands, having an inferior unilocular one-celled ovary, and one erect ovule. It is subdivided by spinous dissepiments or partitions, starting from the placenta, into four cells imperfect at the summit and the base, and into two others imperfect in all its

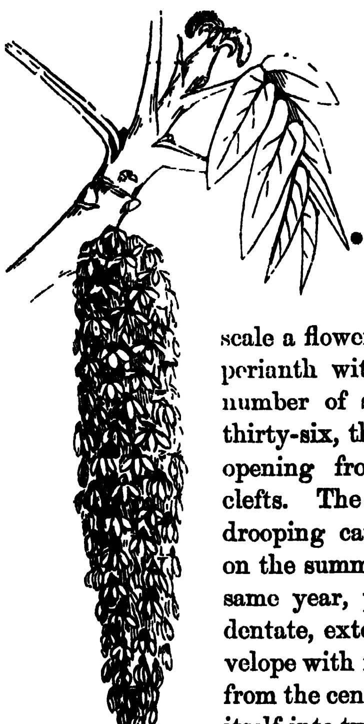


Fig. 387.—Catkin of the Walnut (*Juglans regia*).

remaining extent. The fruit is a drupe; the external covering a fleshy husk of one piece, separating into irregular segments; the nut, a woody shell, is two-valved; of very hard ligneous fibre, furrowed and wrinkled. The seed—single, erect, and wrinkled by the furrows in the shell—is four-lobed at the summit and at the base, which thus separates by dissepiments. The exterior envelope is at first whitish, then yellowish green, more or less spotted, and is then remarkable for its astringent properties; at the earlier stage it is selected for pickling. The embryo is destitute of albumen, and erect; the cotyledons thick, fleshy, oily, bilobed, resembling in figure the convolutions presented by the partuosities of the brain of a vertebrated animal. It is these cotyledons which form the nut.

The Walnut-tree was known to the Greeks, and cultivated by the Romans, by whom it was much valued for its wood as well as for its nut. There is no record of its introduction into Britain; but Gerarde tells us that "the green and tender nuts, boyled in sugar and eaten as suckade, are a most pleasant and delectable meat, comforting to the stomach, and expelling poyson." Before the introduction of mahogany and rose-wood, walnut was in great estimation, and within the last few years it has been restored to its old pre-eminence, its favourite purpose, however, being for gun-stocks, for which its lightness is its qualification. In many parts of Spain, France, Italy, and Germany, the nut forms a great article of food to the people. In all these countries the Walnut-tree is extensively cultivated; the district of the Bergstrasse, between Heidelberg and Darmstadt, is almost entirely planted with them, and in some places, according to Evelyn, in his days "no young farmer is permitted to marry a wife until he brings proof that he is father of a stated number of Walnut-trees." We need not enlarge on the well-known fruit, although we may quote Cowley on its virtues:—

> "On barren scalps she makes fresh honours grow.
> Her timber is for various uses good:
> The carver she supplies with useful wood:
> She makes the painter's fading colours last.
> A table she affords us, and repast;
> E'en while we feast, her oil our lamp supplies.
> The rankest poison by her virtues dies."

The Common Walnut (*Juglans regia*) was originally a native of Persia and the East; there are besides four genera and twenty-seven species, some of them belonging to East India, Persia, Cashmere, and the West Indian Islands, but most of them are American.

GARRYALS.

Diclinous Exogens, with a single floral envelope; sometimes with amentaceous flowers, carpels inferior, a minute embryo in a large mass of albumen. There are only two orders in this group, three genera, and seven species.

Exogenous shrubs of the Western Hemisphere, having their flowers arranged in long pendulous racemes or catkins, unisexual flowers, opposite leaves, and non-stipulate; within concentric rings or dotted ducts.	XCVII. Garryaceæ.
Exogenous shrubs of Japan, of which only one species is known, the *Helwingia ruscriflora* of Japan, with flowers fasciculated on the midrib, and alternate stipulated leaves.	XCVIII. Helwingiaceæ.

MENISPERMALS.

Diclinous Exogens with monodichlamydeous flowers, disunited carpels, and embryo surrounded with abundant albumen, distinguished externally by their scrambling habit, and unisexual flowers, connecting them with Cucurbitals in the one direction, and the Nutmegs and Anonæ in another.

Aromatic trees or shrubs, with apetalous flowers, periginous stamens, pendulous seeds, and minute embryo at the end of a copious fleshy albumen.	XCIX. Monimiaceæ.
Exogenous trees of Australia and Chili, with axillary flowers forming short racemes, with large deciduous bracts, tubular calyx divided into segments at the top, the anthers opening by recurved valves, as in the laurels and Barberry.	C. Antherospermaceæ.
Tropical exogenous trees, with axillary inflorescence, terminating in racemes or panicles, small unisexual flowers, often with one short cowl-shaped bract, as in Columbine.	CI. Myristicaceæ.
Smooth shining exogenous shrubs, with alternate compound leaves without stipules, parietal seeds, minute embryo in abundant albumen. With the exception of *Burasiæ*, a Madagascar genera, they belong to temperate America and Asia.	CII. Lardizabalaceæ.
Scrambling exogenous shrubs of the Indian Isles and hotter parts of North America, with hypogynous stamens, pendulous seed, and minute albumen enclosed in abundant solid albumen; fruit, numerous clusters of berries, one or two-seeded, nestling in pulp embryo in the base of abundant solid albumen. Natives of tropical America and the Indian Isles.	CIII. Schizandraceæ.
A numerous order of exogenous shrubs, with tough flexible tissue and sarmentaceous habit, entire alternate leaves, sometimes palmate, nerved as in *Cissampelos tropæolifolium*; flowers small, racemes diœcious, not always unisexual, rarely bisexual or polygamous.	CIV. Menispermaceæ.

The Menispermals, while possessing many features in common present very extreme differences of structural arrangement, which led Dr. Lindley to adopt the following division of the group. I. *Heteroclineæ,* having the embryo homotropous; cotyledons foliaceous. II. *Anospermeæ:* sepals imbricate or overlapping; embryo transverse; cotyledons accumbent, curved; albumen abundant round the embryo. III. *Tiliacoreæ:* inner row of sepals valvate in æstivation; embryo bent or curved; cotyledons long, narrow, and incumbent; radicle short and curved. IV. *Leptogoneæ*. sepals imbricate in æstivation; stamens distinct or united in a central column; embryo bent or curved; cotyledons long, slender, curved in a form nearly annular; albumen simple and small in quantity. V. *Platygoneæ*: embryo curved; cotyledons elongated, flat, incumbent, curved in a horse-shoe form, enclosed in albumen, small in quantity. VI. *Pachygoneæ:* inner row of sepals often imbricate, sometimes valvate in æstivation; embryo without albumen; cotyledons large, thick, fleshy, incumbent, curved hemicyclically; radicle small. The plants of this order are common within the tropics in Asia and America; climbing among the forest trees to a great height, and remarkably tenacious of life—broken branches throwing out slender thread-like shoots, which rapidly establish a connection with the soil. Forty-four genera, and three hundred and two species.

Cucurbitals.

Diclinous Exogens, with monodichlamydous flowers, inferior ovary, placenta more or less parietal, embryo without any trace of albumen.

The Cucumbers are a natural order of climbing or trailing plants, with unisexual monopetalous flowers, parietal placentæ, and pulpy fruit, climbing by means of tendrils formed of abortive shoots, stipules succulent, palmate ribbed leaves; they are natives of hot countries, chiefly within the tropics of both hemispheres.	CV. Cucurbitaceæ.
Herbaceous branching exogenous plants or trees of considerable size, with apetalous flowers, parietal placentæ, and dry fruit. The few species which constitute the order are natives of North America, Siberia, Northern India, the Indian Archipelago, and South-east Europe.	CVI. Datiscaceæ.
Herbaceous exogens, or under shrubs, leaves alternate, toothed, oblique at the base; stipules large, scarious; flowers unisexual in cymes. Some of the species resemble the Cucurbiteæ in their climbing habits, having been observed scrambling up trees and shrubs to the height of 30 feet.	CVII. Bigoniaceæ.

The Cucurbitals, either climbing by means of tendrils, or trailing plants with unisexual flowers, have scabrous stems and leaves, a

lobed foliage, pulpy fruit with parietal placentæ. The group comprehends the Melon, Cucumber, Colocynth, Bryony, and other genera, of which Dr. Royle remarks that "they afford large and juicy fruit in the midst of the Indian desert and on the sandy islands of Indian rivers; nor does excessive moisture appear to be injurious, as the majority of them are cultivated in the rainy season, and even on the bed of weeds floating on the Cashmere lakes." Two principles pervade them; the one saccharine and nutritious, the other bitter, acrid, and purgative. In the Melon, the Gourd, and their allies, the first exist almost exclusively; but even here accompanied in some degree by a laxative principle. In the Colocynth, Bottle Gourd, and in some of the Luffa and Bryony, the bitter principle is strongly concentrated.

The native country of the Melon is doubtful, although Linnæus places it in Tartary. To the Cucumber the same nativity is ascribed, but in each case without corroborative authority. The Colocynth Gourd, yielding the well-known medicine, grows wild in Egypt and the countries of the Grecian Archipelago. The Water Melon, *Cucumis citrullus*, is extensively cultivated all over Indian and tropical countries of Africa and America.

The CUCURBITACEÆ embracing the Cucumber, Melon, and some kinds of Gourd, are species of the *Cucumis*. Their forms vary considerably. Their culture appears to be as ancient in Asia as that of the most ancient of vegetables. Their characteristics are: the flowers monœcious, the male flowers solitary, growing at the axils of the leaves, or more often fasciculated by the contraction of the common peduncle, the calyx cylindrical, hollow, and campanulate, with five toothed and five ovoid acute and spreading petals. There are three free stamens, two being entire, binocular, the other unilocular, with anther-celled flexuoils, a prolonged connective above the anthers, having a soft oblong superficial gland, simple in the one stamen, unilocular or bifid in the others. The female flowers are solitary, and composed of a fine dentate calyx, a corolla analogous to that of the flower stamens, with an inferior three-celled ovary, surmounted by a short style with three thick stigmata. The ovarium was originally unilocular, with three parietal placentæ, charged each with two series of ovules, which are advanced towards the centre of the cavity, where they are reunited, and

where they soon become fleshy. The fruit is a smooth or warted fleshy berry. The seeds are oval, more or less compressed, and containing a straight embryo destitute of albumen.

The *Cucumis* are herbs with simple alternate leaves, each having a lateral tendril. The Melon is an annual *Cucumis*, cordate at the base, sometimes reniform, sometimes three, five, or seven lobed, with a rounded sinus. Its fruit, which varies very much in shape, generally encloses a sweet fleshy substance, and many are without prickles. It is principally upon the modifications of the fruit that the classification of the Melons into several tribes has been adopted. They are again sub-divided into secondary groups, of which we will give a rapid glance.

The Cantaloupe Melons form a group rather characteristic. In the principal varieties, the fruit is of large dimensions, varying in shape from that of a very depressed sphere to an ovoid oblong, more or less prominent, with smooth or warty skin. The flesh of the Melon, properly speaking, is thick, of a reddish orange colour, delicate, melting, and succulent. All these Melons turn yellow when ripening, and then exhale an agreeable odour.

Another group is that of the Ribbed Melon, which comprises the Market Melon, and some others cultivated largely in the gardens round London and Paris.

The Sugary Melons are ranked in the third class. Their flesh is white or greenish, with a sweeter and more penetrating perfume than the Cantaloupes; they are also delicate, melting, and sugary. The Winter Melons form a fourth group, of which the finest European representative is the Winter Melon of Provence, or Cavailon Melon. The skin of this variety is thin, and its flesh very thick and firm, and of a white, pale, yellowish-green colour; according to the variety, without perfume, but melting and very sweet. It is highly esteemed in the South of France and Europe, where it is cultivated on a large scale. This excellent fruit absolutely encumbers the markets of the South of France during a great part of the summer and autumn. It is also being introduced into Paris. But we must pause in our enumeration of these alimentary fruits, or we should pass the limits of this work.

Another species of the *Cucumis* tribe is the tribe of Cucumbers (*Cucumis sativa*), the young fruits of which, preserved in vinegar,

appear on our tables as a condiment, under the name of Gherkins; and the Cucumber, as it is now produced in gentlemen's gardens, as well as in our market gardens, is a triumph of art over nature.

Many other species of the family of the *Cucurbitaceæ* are worthy

Fig. 388.—Male and Female Flowers of the Melon

of an attentive examination. Among these we may mention the great American Gourd (*C. maxima*), the Pumpkin (*C melopepo*), the Gourd of St. John (*C. pepo*).

The genus *Citrullus* furnishes us with the Water Melon, a large, globular, smooth, green fruit, with a sweet and acid flavour, and a very refreshing odour. The *Cucumis colocynthis*, whose globular, glabrous, yellow fruit, with thin rind and very bitter flesh, is at once a purgative and a vomit. The *Bryonia dioica*, one species of which, commonly known under the name, decorates our hedges with its charming little round, red, sometimes yellow,

berries. It is a perennial, with large succulent roots, from which springs a slender, pale green, hairy stem, which climbs among bushes by means of its tendrils, after the manner of the Cucumbers. The leaves are palmate and rough on both sides, with callous points. The stamens and pistils are on different plants, the stamen-flowers being largest, with bluish pale-green veins. The pistiliferous flowers are succeeded by the berries.

Papayals.

Diclinous exogens, with dichlamydeous flowers, superior carpels, consolidated placentæ, parietal embryo, surrounded by abundant albumen. Eleven genera; twenty-nine species.

Exogenous trees and shrubs, with monopetalous flowers without scales, with alternate lobed leaves, and long taper petioles; flowers unisexual in axillary racemes, sometimes solitary, with free ovary, five parietal placentæ, albuminous seeds.	CVIII. Papayaceæ.
Exogenous trees, having alternate leaves, stalked, entire, somewhat lobed, polypetalous unisexual axillary flowers, solitary, in bundles, or in few flowering racemes.	CIX. Pangiaceæ.

The Papaw-tree (*Carica Papaya*) has the singular property, according to Dr. Hooker, of rendering the toughest animal substances tender; newly-killed meat, suspended among its branches, becomes tender in a wonderfully short time. Old hogs and poultry soon fatten when fed upon its leaves; the leaves are also used by the negroes as a substitute for soap. Some of the Caraya are deadly poisons.

The Pangiaceæ are mostly natives of the hotter parts of India. All are poisonous plants, but contain valuable medicinal properties.

Hypogynous Exogens.

The insertion of the stamens below the ovary in plants has been considered of systematic importance by many French botanists, which has led Dr. Lindley to establish this Sub-Class. They are distinguished by the total absence of floral envelopes, and among them the presence of petals seems to be of little moment. Flowers bisexual, unisexual, separate or on the same plant; stamens entirely free from the calyx or corolla.

Violals.

Hypogynous exogens, with monodichlamydeous flowers, parietal or sutural placentæ; embryo straight, with little or no albumen.

Shrubs or small trees, with alternate simple leaves or short stalks, non-stipulate, frequently entire, leathery, and marked with transparent dots; scattered apetalous or polypetalous flowers; hypogynous petals and stamens; twice as many, or some multiple of the stamens Almost all the order are natives of the hotter parts of the East and West Indies and Africa, two or three of the Cape, and two of New Zealand. They are generally useful plants, yielding wholesome fruits, and some are, as the seeds of Bexa Orellana, which yields arnatto dye, useful to commerce.	CX. Faltiaceæ.
Oxogens, consisting of small trees or shrubs, with apetalous polygamous flowers, disposed in clustered axillary catkins and unilateral stamens; corolla wanting, its peculiar character being the presence of a distinct perianth.	CXI. Lacestemaceæ.
Trees or shrubby exogens, with scattered apetalous and tubular flowers, perigynous stamens with round and linear transparent dots on the leaves. Petals are unknown in the order; but De Candolle considered a petaloid layer which covers the inner surface of the sepals as analogous to a corolla. Many of them are possessed of medicinal properties.	CXII. Samydaceæ.
Herbaceous or shrubby exogens, with polypetalous or apetalous coroneted flowers, perigynous imbricated petals, stamens inserted in the stock of the ovary, simple terminal styles, arillated seed—that is, the seed is enveloped in a cellular aftergrowth, which covers the foramen; leaves alternate, with foliaceous stipules. Nothing struck the companions of Columbus with more surprise than the singularly beautiful Passion-flower, as they named the plant when they first saw it in the South American woods, climbing from tree to tree in all the splendour of its cruciform flower.	CXIII. Passifloraceæ.
Herbaceous or half shrubby exogens, with polypetalous coroneted flowers, axillary or terminal and solitary blue or yellow, alternate non-stipulate leaves, lobed stamens inserted in the stalk of the ovary, simple dorsal styles, seeds without aril. They are all native of Chili and Peru, and little known.	CXIV. Malesherbiaceæ.
Exogenous trees, with two three-pinnate leaves, a many-leafed calyx, perigynous petals and stamens; anthers simple, one-celled, with a thick convex connective fruit; a pod-like capsule; seeds numerous; embryo amygdaloid, without albumen; cotyledons fleshy. The species known are natives of the East Indies and Arabia.	CXV. Moringaceæ.

Herbaceous plants and shrubby exogens, with polypetalous flowers, a many-leaved calyx, hypogynous petals, perfect stamens, anthers crested and turned inwards, consolidated fruit and albuminous seeds. The order is divided into (I.) VIOLEÆ, which are chiefly Siberian and American plants, and a few to tropical Asia. The tropical species are chiefly shrubs, the northern Violets being all herbaceous, or nearly so. (II.) ALSODEÆ, chiefly South American and African, while Pentaloba belongs to the Malayan Flora.	CXVI. Crolaceæ.
Undershrubs and herbaceous exogens, with polypetalous flowers, sessile in the divisions of the branches, and terminal in leaves, usually pink, a tubular furrowed calyx, petals hypogynous, unguiculate, or tapering at the base. They are found in the South of Europe, at the Cape, South America, and Australia.	CXVII. Frankeniaceæ.
Exogenous shrubs or herbs, with rod-like branches, polypetalous flowers in close spikes or racemes, a many-leaved calyx, hypogynous pet inserted at the base of the calyx, distinct styles, consolidated fruit, se ascending, comose, without albumen. The greater number of species are found on the shores of the Mediterranean; they possess some remarkable chemical properties. A pure mucilaginous sugar is produced by exudation from the branches of Tamarix Gallica by a species of coccus, which is supposed to be the manna of Scripture.	CXVIII. Tamaricaceæ.
Exogenous herbs or smooth shrubs, with polypetalous flowers, generally borne in terminal panicles or racemes, on slender thread-like stalks, a many-leaved calyx, hypogynous petals, stamens partly sterile and petaloid, anthers turning outwards opposite the petals, naked, a consolidated fruit and albuminous seed. The species are natives of Brazil, Peru, and the West Indies, but little is known of their properties.	CXIX. Sauvagesicaceæ.
Succulent exogenous herbs and shrubs, with polypetalous and monopetalous flowers, usually sessile in cymes, often arranged on one side only along the divisions of the cyme, leaves entire or pinnatified, non-stipulate, calyx many-leaved, petals hypogynous, fruit in follicules opening at the suture. Some singular examples of structural variations are related of the Houseleeks. In *Semper vivum* Adolphe Brongniart found little bundles of annular and spiral vessels immediately round the pith, and outside of them fusiform woody fibres, with five four-sided dots, arranged in radiating rows and inturning lines, with parcels of annular and reticulated vessels. In *Crassula pertulacaceæ* he found no woody zone at all; the hard tissue which is found in regular concentric circles of dotted woody fibre in other species is here entirely wanting. Schleiden found in an old stem of Echeveria an entire uniform mass of wood, formed of parenchyma without vessels, with vertical cords of three-sided parenchyma, in the midst of which ran spiral vessels, most of which might still be unrolled. Of this large order, 133 belong to the Cape of Good Hope, four to South America beyond the tropics, and the others to Mexico, the West Indies, the Canaries, China, Japan, and Europe.	CXX. Crassulaceæ.
Herbaceous exogens, with polypetalous axillary flowers, perigynous contorted yellowish, rarely blue, petals, inferior calyx, often coloured, forked styles, and nonstipulate leaves. They are natives of the West Indies and South America.	CXXI. Turneraceæ.

This important group of Orders, with three exceptions, form, as Dr. Lindley informs us, a perfectly natural group, the exceptions being the *Moringaceæ*, the *Tamaricaceæ*, and the *Sauvagesicaceæ*. The *Flacourtiaceæ* are small trees or shrubs, natives of the hottest parts of the East and West Indies, and Africa. The *Lacestemaceæ* grow in low places in equinoctial America. The *Lamydaceæ* are all tropical, and chiefly American. "The *Passifloràceæ*," says Dr. Lindley, "are the pride of South America and the West Indies, where the woods are filled with their species, which climb from tree to tree, bearing at one time flowers of striking beauty, and of so singular an appearance, that the zealous Catholics who

first discovered them, adapted to these inhabitants of the American wilderness their own Christian traditions, at other times, fruit, tempting to the eye and refreshing to the palate."

The name is derived from a fancied resemblance to the cross, the emblem of our Saviour's crucifixion. In the five anthers, the Spanish monks saw His wounds; in the triple style the three nails by which He was fixed to the cross; and in the column on which the ovary is raised, the pillar to which He was bound; while a number of filaments which spread from the cap within the flower were finally likened to the crown of thorns. In reality, the flower consists of a calyx and corolla, each of five divisions, consolidated into a cup, from within the rim of which spreads several rows of filamentous processes, regarded by some as barren stamens. From the sides of the cup, and within these, there proceeds one or more raised rings, notched or undivided, and in various degrees of development, and of the same nature as the filamental processes. In the centre of the flower stands a column, to the sides of which the five stamens are united, but spreading freely beyond its apex, and bearing five oblong horizontal anthers. The axis of the columns bears the ovary, a one-celled vase, with three parietal polyspermous placentæ, having three club-shaped styles at its vertex. The plant produces a gourd-like fruit, containing many seeds, each having its own fleshy aril, usually enveloped in a sub-acid mucilage.

The medicinal properties of *Passiflora* are considerable. The soothing influence of *P. contrayerva* is well known to those having the care of children, and almost all the species have properties of a useful character.

The *Malesherbiaceæ* are half-hardy herbaceous plants of Chili and Peru, of little known interest.

The *Moringaceæ* are a small group of trees of the East Indies and Arabia, which De Candolle placed with the *Leguminaceæ*, erroneously, as Dr. Lindley thinks.

The VIOLACEÆ, of which group the Violet (Fig. 389), is a type, have irregular flowers, each having two bracts. The calyx has five sepals, each of them having a small open disc at its base, which descends beyond the point of its insertion. The corolla is composed of five petals, the inferior and largest being hollowed

out, and terminated at its base by a short and obtuse spur, which is directed downwards by two lateral ones, which are entire and barbate. The two upper petals, which are equally entire, are directed upwards. There are five stamens alternating with the petals; they are nearly sessile, and lightly joined by their anthers, which are bilocular, and open from within by two longitudinal clefts. Each anther is surmounted by a little thin yellow tongue, which is a prolongation of the connective. In addition to this, two of the anterior stamens are provided at their base with a kind of tail, which lodges in the hollow horny substance of the lower

Fig. 389 —The Violet.

petal. The pistil is composed of a free ovarium, surmounted by an ascending style, swelling a little above the base, and terminating in a vergate or rod-like hooked stigmata. In the interior of the ovarium, which is unilocular, are three parietal placentæ, charged with straight anatropal ovules.

The fruit is a capsule, which opens in three valves, each having a placenta in their midst. The seeds contain a straight embryo in the axis of a fleshy albumen.

The Violet is a very short-stemmed plant, since its height never reaches more than from 3 or 4 inches. Its leaves, which are radical, or growing upon suckers, are acutely or ovoidaly crenulate, or heart-shaped. The stipules are oval, accuminate, or lanceolate. The flowers have a sweet odourous aroma, of a violet or reddish blue colour, each borne upon a slender peduncle, which is returned at the summit. Such is the Violet (*Viola odorata*, as in Fig. 389), to the botanist; the poet would give a very different description of it.

It is well known that there are many other species of this plant which, to the disappointment of many, are inodorous; such are *Wood Violet*, the *Dog Violet*, &c.

But what of the Pansy? This pretty little plant also belongs to the Violet tribe, or to a section of it. In the Pansy the upper petals and laterals are directed above, and only the lower one is directed below, and generally the stigmata is inceolate and globulous.

There are two varieties of the Pansy, or *Viola tricolor*. The Wild Pansy, the corolla of which does not overreach the calyx; the other the Garden Pansy, the petals of which more or less overreach the calyx. The size and colour of the Pansy have been greatly varied by cultivation.

The CRASSULACEÆ comprehend the plants commonly known as Houseleeks, on account of the quantity of water which they enclose in their tissues, and the general thickness of their leaves, which is supposed to give them a resemblance to the Leek, and from their properties. The *Orpine*, or Biting Stonecrop (*Sedum acre*), Fig. 390, will serve as a type of the family. It is a little fleshy plant, being common upon old walls, thatched roofs, and stony and gritty places which are exposed to the sun. It has a slender subterranean stem, recumbent and creeping, throwing up branches here and there, covered with short, straight, sessile, and fleshy leaves resembling little eggs slightly flattened at the top, and bearing five or six flowers disposed in a series of terminal branching corymbs.

What, then, is the organisation of these flowers? They have each a calyx composed of five fleshy pieces, five free petals, and double the number of stamens, with flattened runners pointed at the summit, bilocular anthers, pointing back at their axis; lastly,

a pistil composed of five free unilocular carpels, enclosing many anatropal horizontal ovules inserted on the ventral suture of each carpel. At maturity these bodies become dry, and open from within by this suture in such a manner as to constitute a like number of follicles, which enclose extremely small seeds.

Fig 390 —Sedum acre.

This little herb, as we have said, may be considered as a type of the CRASSULACEÆ. These singular plants grow and keep fresh in the most arid places, from the mass of liquids held in reserve in their fleshy tissues, and from the almost total absence of all exhalation.

The genus *Crassula*, which has given its name to the family, is remarkable for the structure of its flowers, which have been taken as a type of floral symmetry. This flower has five sepals with five petals alternating with them; five stamens alternating with the petals, and five carpels alternating with the stamens. The Houseleeks belong to the genus *Sempervivum*, the calyx of which has from six to twenty divisions, the corolla from six to twenty petals, the andraceum twelve to forty stamens, the pistil with from six to twenty carpels.

All of us have seen this beautiful plant creeping along the thatch of cottages, with its succulent leaves disposed in a rosette, from the centre of which rises a straight cylindrical stem, garnished with thick fleshy leaves, and terminating by a scorpoide spike of purplish flowers.

Among the numerous exotic specimens with which this family furnishes horticulture, we may mention the Scarlet Crassula, the

White Crassula of the Cape, and the Spurious-Leaved Rochea, from the same botanical region. This is a shrub which produces a handsome red flower, odorous and of long duration, the *Cotyledon orbiculata,* with glaucous, farinaceous leaves edged with red, having a corolla with reddish limb rolled from the outside. The Scarlet Echeveria, from Mexico, has leaves in rosettes, and flowers of a lively red, disposed in branching cymes.

The Crassulaceæ are found "in the driest situations, where not a blade of grass or even of moss can grow; on naked rocks, old walls, hot, sandy plains, exposed to heavy dews by night, and to the fiercest rays of the noonday sun. Soil is to them something to keep them stationary, rather than a source of nutriment, which in these plants is conveyed by myriads of mouths to the juicy beds of cellular tissue which lie beneath them, invisible to the naked eye, but covering all their surface."

CISTALS.

A group of hypogynous exogens, with monodichlamydeous flowers, parietal or sutural placentæ, and a curved or spiral embryo with little or no albumen.

Shrubs or herbaceous exogens, with trimerous or pentamerous flowers, stamens usually definite, hypogynous, distinct, and never tetradynamous, fruit closed up, seeds albuminous. The Rock Roses are natives of the South of Europe and North of Africa, and South America, and rarely in North America.	CXXII. Cistaceæ
Herbaceous annual, biennial, and perennial exogens, with tetramerous, or four-parted flowers and stamens. Embryo with the radicle folding upon the cotyledons, which are sometimes slit or lobed. Crucifers have their stamens arranged so that two stand opposite each of the posterior and anterior sepals, and one opposite each of the lateral sepals, there being thus six stamens to four sepals, and not four or eight	CXXIII. Cruciferæ
Soft herbaceous or shrubby exogens, with definite flowers in racemes or spikes, many parted calyx, petals broad, fleshy plates, seeds without albumen, and fruit open at the pores. In Mignonette and others of the order, the stamens grow out of a large glandular one-sided plate.	CXXIV. Resedaceæ.
Herbaceous exogens, shrubs and trees, petals four or eight, unguiculate and unequal, flowers solitary or racemose, seeds exalbuminous, and closed-up fruit. They are chiefly natives of the tropics or countries bordering on them, their fruit is fleshy and indehiscent, with parietal polyspermous placentæ.	CXXV. Capparidaceæ

The Cistals are chiefly European, and possess anti-scorbutic and stimulating properties, combined with an acrid flavour, and in their decay they give out large portions of nitrogen. Mustard, Cress, Seakale, and the Cabbages, Radish, and Turnip, are well-

known species belonging to the order, which contain 173 genera and 1,600 species.

The CRUCIFERÆ is one of the most natural groups of the whole vegetable world, and in studying one of the species which compose it we may study all. Let us take as a type one flower, the Wallflower (Fig. 391). This flower is regular. The calyx is composed of four sepals, free and straight, the two lateral bulging out at the base. The corolla has four unguiculate petals alternating with the sepals, and limbs which are patulous throughout. The stamens are tetradynamous, that is to say, they number six, of which four are large and two smaller; they are also hypogynous. Their anthers are bilocular, and open from within by two longitudinal clefts. At their base is a disc composed of glands, two of which are of a greenish colour, enclosing, so to speak, two little stamens, whilst the other four are smaller, and are placed on the outside of the long stamens. The pistil is composed of a very elongated ovary, surmounted by a rather short style, of which the stigmate is bilo-

Fig. 391 —The Wallflower.

bate. When at maturity this ovary presents two cells. It is, however, unilocular when young, with two parietal placentæ, filled with ovules. At a certain period of its development it has only one gland starting from one of these two parietal placentæ, and advancing towards the interior it meets the gland of the opposite placenta and is joined to it, and this constitutes a dissepiment which separates the ovarian cavity into two compartments. When arrived at maturity this ovary becomes a *siliqua,* as the long pod of the Cruciferæ is termed; when these seeds, which are destitute of albumen, enclose an embryo with flat cotyledons and lateral roots, that is to say folded upon the commissure of the cotyledons, or face by which the carpels adhere.

We have already said that the family of the Cruciferæ is constructed upon one great common type. There are nevertheless some secondary characters, arising from the regularity or irregularity of the corolla, the shape of the fruit and of the embryo, which serve to distinguish the different genera; for example, the *Iberis* have two petals much larger than the others. Then the fruit, which in the Wallflower is a siliqua, is a silicula, or as broad as long, in the *Thlaspi,* when it becomes Lomentaceous; *i.e.* an indehiscent legume in the *Raphanus,* monospermous and indehiscent in the *Isatis,* &c. With regard to the embryo, the radicle does not always fold upon the commissure of the two cotyledons as it does in the Wallflower; it is sometimes folded upon their back, as in the *Isatis,* whose cotyledons are not level, but are folded longitudinally, and rolled back upon themselves. Among the more remarkable plants belonging to this vast vegetable family, we will mention the *Cochleria officinalis,* which is a most powerful antiscorbutic; the Garden Cress (*Lepidium sativium*); the Water-cress, (*Nasturtium Officinale*); the Horse radish (*Cochlearia amoracia*); the Radish (*Raphanus sativus*), of which two varieties (the turnip and long Radish) appear at our tables; the long Cabbage (the fleshy roots of which are a little acid and sweetish); the Colza (*Brassica oleifera*), the seeds of which furnish an excellent lamp-oil; the Garden Cabbage (*Brassica oleracea*), which furnishes us with the Cabbage, the Cauliflower, the Brocoli; the Black Mustard (*Sinapis nigra*), the seeds of which afford a volatile oil, to which they owe their exciting

virtue; the Woad (*Isatis tinctoria*), the blue roots of which furnish a colouring matter called *woad;* various specimens of *Lunaria* and *Erisium*, *Mathiola*, *Chenanthus*, and *Hesperes*, are cultivated as ornamental plants. Nearly all plants of the family of the Crucifers contain a juice of an acrid and piquant flavour, due to the presence of a volatile oil, which though it exists under all circumstances, becomes more developed under the influence of hot water, as seen in mustard seed. The presence of this acrid and exciting oil communicates to the plants of this family the anti-scorbutic virtues which medicine ascribes to them. Some Crucifers are employed as aliments on account of the mucilaginous and saccharine matter which they contain, and which corrects the acridity of their juices; others furnish a lamp-oil from their seeds, which is much used. The plants of this family are very little cultivated for ornamental purposes, although some remarkably pretty flowers are found within its limits. For fragrant aroma few plants excel the Wallflower. Who does not remember

> "Some rude stone fence, with fragrant Wallflower gay,"

or the bright green shining *Cardamine pratensis*—the

> "Ladies' smock, all silver white,"

whose praises Shakespeare sung?

The RESEDACEÆ, of which the common Mignonette (*Reseda odorata*) may be considered the type, are soft herbaceous plants, or, in a few instances, small shrubs, with alternate entire or pinnate leaves and minute gland-like stipules; flowers in racemes or spikes; calyx many-parted; petals broad fleshy plates. They are all natives of the South of Europe and adjoining parts of Asia, and of the shores of the Mediterranean. A few species occur at the Cape, and again in Australia.

The common Mignonette, whose delicious scent has caused it to be universally cultivated, is a native of Northern Africa. It is known by its lanceolate entire trifid leaves, six-parted calyx, equal in length to the petals, which are finely cleft into many club-shaped divisions, the two lowest simple; the capsules three-toothed. Mignonette is naturally a small herb, but it has become the fashion to train it in greenhouses until it becomes a shrubby plant, when it is

called the Tree Mignonette, rising three or four feet from the pot in which it is grown.

The CAPPARIDACEÆ are chiefly found in the countries bordering on the tropics; they resemble Crucifers in being stimulants, anti-scorbutic, and aperient; the principle of acridity becoming so concentrated in some of them as to be dangerous. Some of the African Capparids are poisonous.

MALVALS.

Flowers monodichlamydeous, placentæ axile, calyx valvate in æstivation, corolla imbricated or twisted, stamens definite, embryo with little or no albumen. One hundred and sixty genera; nine hundred and thirty-three species.

Large trees and shrubby exogens, with perfect two-celled stamens, turned outwards. The order is tropical, or at least of hot countries. The Baobab trees of Senegal, remarkable for their enormous size and great longevity, belong to the order. The Bombax of American forests, with huge buttresses projecting from their enormous trunks, belong to the order, and most of the great trees of the order possess valuable properties.	CXXVI. Sterculiaceæ.
Exogenous trees, shrubs, or undershrubs, occasionally with a climbing habit, having monodelphous stamens, partly sterile and two-celled; anthers turned inwards; flowers often in clusters, sometimes in spikes or panicles; calyx four, five-lobed, valvate, in æstivation, or arched and drawn out into a strap; stamens hypogynous, definite, and opposite the petals; fruit generally a capsule. They are natives of tropical countries. The Cacao, a chief ingredient in chocolate, belongs to the order, and many species yield valuable fibres for cordage.	CXXVII. Bythneriaceæ.
Herbaceous, or half-shrubby exogens, with free stamens, without disc, albuminous seeds, embryo curved, permanent petals, and ribbed calyx, flowers white, red, or pink, in panicles or corymbs; calyx ten ribbed, with five valvate divisions; petals with claws, hypogynous; stamens ten, hypogynous, those opposite the sepals inserted in a fleshy gland. The known species are natives of Brazil and Chili. Their properties are little known.	CXXVIII. Vivianiaceæ.
Smooth herbaceous exogens, of tender texture, and trailing or twining habits, with one-flowered axillary peduncles; flowers yellow, scarlet, orange, or blue; free stamens; no disc; seeds without albumen, and an amygdaloid embryo. The Indian Cresses, a name which their acrid taste has procured for them, are natives of temperate America.	CXXIX. Tropæolaceæ.
Exogenous trees, shrubs, and herbaceous plants, with showy flowers, often enclosed in an involucre of various forms, columnar stamens, all perfect, and one-celled anthers turned inward.	CXXX. Malvaceæ.
Exogenous trees and shrubs, with few herbaceous plants, with free stamens outside the disc, albuminous seeds, and straight embryo. Some of them are weed-like plants of the tropics, sometimes with handsome white or pink flowers.	CXXXI. Tiliaceæ.

Among the STERCULIACEÆ, which are large trees or shrubs, all natives of the tropics, having the columnar stamens of the

Mallows, none excited greater surprise than the *Adansonias*, or Baobab trees of Africa, when they were first introduced to the botanical world; their enormous size, and their prodigious longevity, estimated in some instances at some thousands of years, took the world by surprise.

The BAOBAB (*Adansonia digitata*) is a tree of tropical Africa, which has been transplanted by man into Asia and America. It may be ranged among the marvels of nature. Its trunk does not exceed fifteen or eighteen feet in height, but its girth is enormous, attaining, as it sometimes does, the circumference of thirty to forty feet. This trunk separates at the summit into branches fifty to sixty feet long, which bend towards the earth at their extremities. The trunk being short, and the branches thus curving towards the earth, it follows that the Baobab presents at a distance the appearance of a dome, or rather a ball, of verdure, over a circuit of a hundred and sixty feet. Adanson concluded, from the observations he made, and from his calculations upon their growth, that some of the specimens which he studied could not have been less than 6,000 years old. But it is the general opinion of botanists that this estimate was enormously overrated. One of these monstrous trees is represented as photographed from nature in Plate XIV. This colossal vegetable was first observed by Adanson on the Senegal, and, after him, the genus was named *Adansonia*. The Baobabs have since been discovered in the Soudan at Darfour, and in Abyssinia.

The bark and leaves of this tree possess considerable emollient properties, of which the natives of Senegal take advantage. Its flowers are proportioned to the gigantic trunk; they reach the length of four and a half and five inches, their breadth being from seven to eight. The fruit, called by the French settlers on the Senegal *Monkeys' Bread*, is an ovoid capsule, pointed at one of its extremities, and from twelve to twenty inches long, by six to seven broad; that is, the fruit is about the size of a man's head. It encloses in its interior from ten to forty cells, containing several kidney-shaped seeds, surrounded by mucilaginous pulp.

The natives make a daily use of the dried leaves of the Baobab. They mix them with their food, for the purpose of reducing their

excess of perspiration and modifying the ardour of their fiery climate.

The fruit is eatable; its flesh is sweet, and of an agreeable flavour; the juice, when extracted and mixed with sugar, forms a beverage very useful in the putrid and pestilential fevers of the country. The fruit is transported into the eastern and southern parts of Africa, and the Arabs pass it on to the countries round Morocco, whence it finds its way into Egypt. The negroes take part of the damaged fruit and the ligneous bark, burn them for the sake of the ashes, from which they manufacture soap by means of palm oil. They make a still more singular use of the trunk of the Baobab; they expose upon it the bodies of those among them whom they consider unworthy of the honours of sepulture. They select the trunk of some Baobab already attacked and hollowed out by insects or fungi; they increase the cavity, and make in the trunk a kind of chamber, in which they suspend the body. This done, they close up the entrance of this natural tomb with a plank. The body becomes perfectly dry in the interior of this cavity, and becomes a perfect mummy without further preparation. This kind of sepulture is especially reserved for the *Guerrots*. The Guerrots are the musicians and poets, who in the tombs of negro kings preside at all fêtes and dances. During their life this kind of talent gives them influence, and makes them respected by other negroes, who look upon them as sorcerers, and honour them under the title; but after death this respect is succeeded by a kind of honour. These superstitious and infantile people imagine that if they consigned the body of one of these sorcerers to the earth, as they would the bodies of other men, that they would draw upon themselves the celestial malediction. Hence the monstrous Baobab serves as the resting-place of the Guerrot. There is a strange poetry in this custom of a barbarous people which leads them to bury their poets between heaven and earth in the side of the vegetable king.

The leaves of *Adansonia digitata* are of a deep green, and divided into five unequal parts, each of which forms a narrow lanceolate figure, radiating from a common centre, the outermost being smallest. The flowers, which grow singly in a pendulous position from the bosom of the leaves, are large and white,

crumpled at the edge, the petals being much reflexed. The stamens numerous, and collected into a tube, which spreads at the top into an umbrella-like head, from which rises a slender curved style, terminating in a rayed stigma.

The various species of Bombax and Ceiba, which also belong to the order, are gigantic American forest-trees, with huge buttresses projecting from their colossal trunks. They are more noted for their appearance than for their properties.

The Malvals, with the exception of the Tilias and Malvas, are trees and shrubs of the tropics. The Indian Cress, *Tropæolum*, include some of our prettiest flowers. The Mallows abound also in the tropics, but many species are common field plants with us, gradually diminishing towards the north. They all abound in mucilage, which is found salutary in cases of irritation. Dr. Asa Gray arranges the order into four tribes, viz. :—1. *Malopeæ*, containing three genera, the *Malopa* of Linnæus being typical. 2. *Malveæ*, containing Althæa, Malva, Sida, Abutilon. 3. *Ureneæ*, containing Malachia, Pavonia, and some doubtful genera. 4. *Hibisceæ*, in which Hibiscus is the typical genera; and the well-known Cotton-plant, *Gossypium*. The genera, however, are not remarkable for any valuable properties, although some of the species, the Cotton-tree of India (*Bombax pentandrum*), yield a useful gum, and several of the species have their seeds wrapped up in woolly hairs, which are usefully employed as stuffing material. The geographical distributors seem to limit the *Sterculeæ* to India and Africa, the *Bombaceæ* to tropical America; the *Helectereæ* seem to be unknown in Africa, but extend to Tasmania and New Zealand.

The BYTHNERIACEÆ are trees, shrubs, sometimes climbers, wholly intertropical. They are natives of Australia, New Zealand, South Africa, Asia, and tropical America, the most remarkable species being *Theobroma cacao,* a small tree, of which Demerara has whole forests. The seeds of this plant form the principal ingredient in chocolate, and an ardent spirit is distilled from the fruit.

The *Vivianiaceæ* are herbaceous and half-shrubby plants of Chili and Brazil, of little interest.

The TROPÆOLACEÆ are smooth, herbaceous, trailing, or twining plants, of tender texture and acrid taste, better known for the

strange form and rich colours of their flowers. They are all natives of North and South America. The flower is distinguished by its irregular spurred calyx (Fig. 392), the spur *s* being a backward development springing from the base of the calyx at *a* in the Indian cress (*Tropæolum magus*).

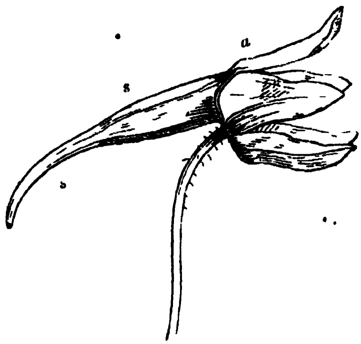


Fig. 392.

The MALVACEÆ are herbaceous plants, trees, and shrubs, with starry flowers, often enclosed in an involucre of various forms. They are abundant in the tropics, diminishing as we approach the north. In our climate the Marsh Mallows are the well-known representatives of the order. The Common Mallow (*Malva sylvestris*, Fig. 393) has the stem straight, ascending or patulous, branching, hairy, prickly, especially at the apex; the inferior leaves somewhat orbicular, heart-shaped, or truncated at the base, having from five to seven lobes, shallow and obtuse; the upper leaves present three to five lobes, usually much deeper; the flowers, the corolla of which is veined with purple, passing to violet, are disposed in axillary fascicules.

Now, what is the organisation of these flowers?

The calyx is in five divisions, and is furnished exteriorly with an involucre in three divisions. Five alternate petals, coherent at the base of their claw, constitute the corolla. The stamens are numerous and monodelphous; that is, they appear as if their unequal filaments, free only in their upper part, were united, their lower parts passing to a tube, covering the ovary. These filaments are surmounted by an unilobate anther, opening by a semicircular cleft. The pistil is composed of a multi-ocular ovary, surrounded by as many styles as there are cells.

These last organs are filiform, consolidated in their lower part, and forming a sort of brush. An ascendant ovule is inserted at the central angle of each of these cells. The fruit is composed of a great number of small husks, each with a single seed connected circularly round a common central axis. Under their integuments

the seeds contain a curved embryo, in a rather abundant mucilaginous albumen, the cotyledons folded upon and fitting into the

Fig 393 —Common Mallow (*Malva sylvestris*).

other. The flowers of the Mallows are largely employed as emollients for coughs, and similar objects.

The Marsh-mallows (*Althæa officinalis*) have stems from three to six inches in height; they are erect, and densely covered with hairy down, as also are the leaves, which are ovoid, dentate, and slightly lobated. The flowers, of a pale rose colour, are generally fasiculate in the axils of the leaves, near the summit of the stem and branches. The fasicle or bundle occurs when numerous flowers are congregated into a thickly set group, as in Fig. 394, where *p* is the petiole or leaf-stalk, *s* the stipule, *b* the bract, *c* the calyx, *cor* the corolla. These flowers are fascicled.

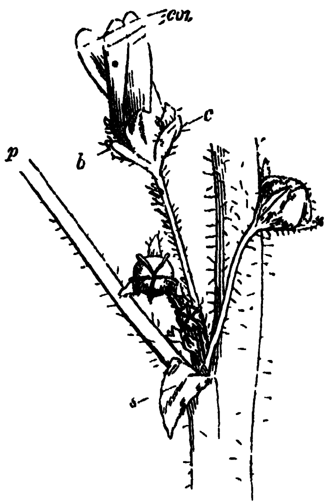


Fig 394 —Common Mallow (*Malva sylvestris*).

The Marsh-mallows are tap-rooted, fusiform, fleshy, and white; they are about the size of a finger, simple, but somewhat branchy. It is an approved and popular medicine, and holds the highest rank as an emollient.

Amongst the most remarkable of the Malvaceæ is the Cotton-tree (*Gossypium*), of which several species are largely cultivated in many parts of Asia, America, and the North of Africa, within the tropics, for the sake of the down which covers the testa of their seeds. This down forms the textile substance known under the name of cotton. The Ketmia (*Hibiscus*) have a five-celled ovary and a five-valved capsular fruit, several species of which form an ornament to our gardens—the Holyhock (*Althæa rosea*), when well grown, being a noble flowering shrub. The young mucilaginous capsule of one amongst them, the *Hibiscus esculentus*, furnishes a stiff and rather insipid stew, very much liked in America. *Malopa, Sida*, and the finely pencilled *Abutilon* are members of the large family of the Malvaceæ, which abound throughout the tropics, and also in Europe; they are interesting in many respects. The uniform properties of the order are, an abundant mucilage, and total absence of deleterious properties. The Mallows and Marsh-mallows of Europe yield a tasteless, colourless decoc-

tion, which is salutary in coughs and other local causes of irritation. The flowers of the Holyhock are used in Greece for the same purpose; various species of *Sida* are used as emollients. *Abutilon esculentum* is used as a vegetable in Brazil. The fruits of others of the order are favourite ingredients in soups. The barks of many, as *Malva crespa*, and several species of *Hibiscus*, yield a strong fibre suitable for cordage. The Holyhock (*Althea rosea*) is said to yield a dye not inferior to indigo, and, to crown the whole, King Cotton is produced by several species of *Gossypium* belonging to the order. There are three varieties of the Cotton plant cultivated in America, namely, the Nankeen Cotton, supposed to be derived from *G. religiosum*, and possessing naturally the yellowish colour which distinguishes it; the Green-seed Cotton, producing white cotton and having green seeds; the Black-seed Cotton, producing white cotton and black seeds. Upland cotton is a fine white variety, known as the *Short Staple* cotton; the third variety is cultivated on the low, sandy islands lying between Charleston and Savannah, and known as the *Sea Island* cotton, long celebrated for its long staple and the high price it produces in the market.* *G. arboreum*, the Tree-cotton, cultivated in India and Africa, small growing,—from four to ten feet high.

The TILIACEÆ or Lindens are trees or shrubs, rarely herbaceous. The Limes, the types of the order, are large trees with light white wood; their leaves, sharply acuminate, ovals dentate, pubescent, or glabrous. They are alternate, distichous, and furnished with caducous stipules. The flowers have this remarkable character, that they are disposed in axillary paucifloral corymbs with peduncle, which in its lower half is consolidated with a whitish membranous bract, and especially for their glandular disc, distinct stamens, and two-celled anthers.

The Common Lime (*Tilia Europæa*) (Plate XV.), usually called the Dutch Linden, is widely disseminated in our woods, whether of plains, hills, or mountains; it is rarely found beyond the altitude of 300 feet above the level of the sea They are planted for their elegant and graceful form and delicious aroma in parks and public promenades. Its buds are velvety, and its mature leaves are slightly pubescent on their lower surface.

The forest Lime (*Tilia sylvestris*), which is planted here and

Plate XV.—The Lime Tree (*Tilia Europæa*).

there in our parks and promenades, and is common in our woods, is easily distinguished from the preceding species by its smooth leaf-buds; its mature leaves are often very small, with smooth or glabrous lower surface, only having bristles at the angles of the ramifications of the veins. But we must pass to the description of the flower (Fig. 395). The calyx consists of five lanceolated sepals, the corolla of five petals longer than the sepals. The

Fig. 395.—Flower of the Lime-tree.

stamens are hypogynous and very numerous, free or irregularly polyadelphous at their base; their elongated filaments bearing two cells, opening from within by two longitudinal clefts. The ovary is free, and generally has five biovulate cells with anatropal ovules. The style is simple, and the stigmata five-lobed. The fruit is acoriaceous, indehiscent, cupular, unilocular by the disappearance of the dissepiment, and only contains two seeds by abortion. The seeds each enclose a fleshy albumen and an embryo, with foliaceous cotyledons nearly rolled up. The flowers of the Lime contain a volatile oil, with sugar, mucilage, gum, and tannin. They are employed in medicine as anti-spasmodics. Of all indigenous

plants the liber of the limes yields the most strongly organised fibre; hence it is extensively employed in making cordage. The wood, which is easily wrought, is employed chiefly by joiners and carvers.

The *Sparmannia Africana,* a pretty flower from the Cape of Good Hope, has evergreen leaves, white flowers disposed in umbella, anthers of the flowers being irritable. The leaves of *Corchorus oletorius* are used in Egypt as a pot-herb. Fishing lines, nets, and a coarse bagging are made from the fibre of *Corchorus capsularis* in India. In general terms the order may be said to abound in plants both useful and ornamental.

Sapindales.

Hypogynous exogens, flowers monodichlamydeous, unsymmetrical; placentæ axile; calyx and corolla imbricated; stamens definite, embryo with little or no albumen. 132 genera, 1,656 species.

... nthers, opening by pores. They are all plants and prope	CXXXII. Tremdudaceæ.
Shrubs or herbaceous and sometimes twining exogens, with complete, but irregular, unsymmetrical flowers, very showy in many Polygalæ, naked petals, one-celled anthers, opening by pores, and caruncululate seeds. The order is widely spread, being represented in Asia by Salmonia and Soulamia; by Muraltia at the Cape; by Monnina and Badiera in South America. Comesperma is found in Brazil and Australia. Polygala occurs in Cayenne and on the Swiss mountains. The order is anomalous, and scarcely forms a natural group; many of the genera have claims to separation, although it is difficult to find more suitable places for them in the system.	CXXXIII. Polygalaceæ.
Exogenous trees and shrubs, with complete, unsymmetrical, very irregular, large, and gaily coloured flowers, usually in terminal panicles or racemes, naked petals, anthers opening longitudinally, three carpels, and winged seeds. They are all natives of the forests of equinoctial America, their habitat being the banks of the streams, sometimes rising up mountains to a considerable height, conspicuous by their large spreading heads, as described by Schomburgh.	CXXXIV. Vochyaceæ.
Exogenous shrubs, with partially complete symmetrical flowers in terminal stalked racemes; an imbricated calyx, ascending ovules, simple stigmas, opposite leaves with stipules. The few known species of Bladder-nuts are scattered over the globe. Of the Staphylea, one is known in Europe, one in North America, one in Japan, two in Jamaica, one in Peru.	CXXXV. Staphyleaceæ.
Exogenous trees of considerable size, or twining shrubs bearing tendrils; sometimes climbing plants, with complete unsymmetrical flowers in racemes, or racemous panicles; petals usually with an appendage, anthers opening longitudinally; three carpels; and usually axillate and wingless seeds.	CXXXVI. Sapindaceæ.
Exogenous undershrubs, or herbaceous plants, with an alliaceous odour, having apetalous racemose or panicled flowers, and solitary carpel, with stipules; straight embryo without albumen, and spiral cotyledons. They are chiefly natives of West Indian or tropical America.	CXXXVII. Petiveriaceæ.

The Maples are exogenous trees, with complete unsymmetrical, often polygamous flowers, in axillary racemes or corymbs;[1] petals naked, equal to the lobes of the calyx; anthers opening longitudinally; two carpels, and seeds without an axil.	CXXXVIII. Aceraceæ.
Exogenous trees and shrubs, often having a climbing habit, with complete, partially symmetrical flowers; imbricated calyx; naked, stalked petals; ovules hanging by cords; simple stigma; and convolute embryo. Many of the trees of this order are beautiful trees or climbers, with gaudy flowers, some of them yielding fruits, others with valuable medicinal properties. They are all tropical.	CXXXIX. Malpighiaceæ.
Exogenous shrubs or trees, with complete, partially symmetrical whitish green flowers, growing from among small imbricated scales; an imbricated calyx; petals with an appendage; sessile pendulous ovules; capitate stigmas; and straight embryo. They are principally natives of the West Indies or South America, chiefly Brazil, a few East Indian, and one of Australia.	CXL. Erythropylaceæ.

In skimming over the surface of the vegetable world, as our limited space compels us to do, we necessarily leave unnoticed a vast number of genera interesting alike for their properties, for their beauties, and for the physiological peculiarities they present. Among the sapinaceous plants, for instance, we find genera so anomalous that botanists can only link them together in the system by the discovery that the three pieces which constitute their calyx are in reality five, two petal-like bodies lying within the sepals being part of the calyx. They are natives, for the most part, of the tropics, especially of South America, India, and Africa. While many species yield most delicious fruits, others are deadly poisons, even where the fruit is safe and delicious—*Sapindus Senegalensis*, for instance: the seeds are known to be poisonous to man and beast. Amid structures so diversified their properties are equally so. The greater part are bitter, and the roots milky; even the

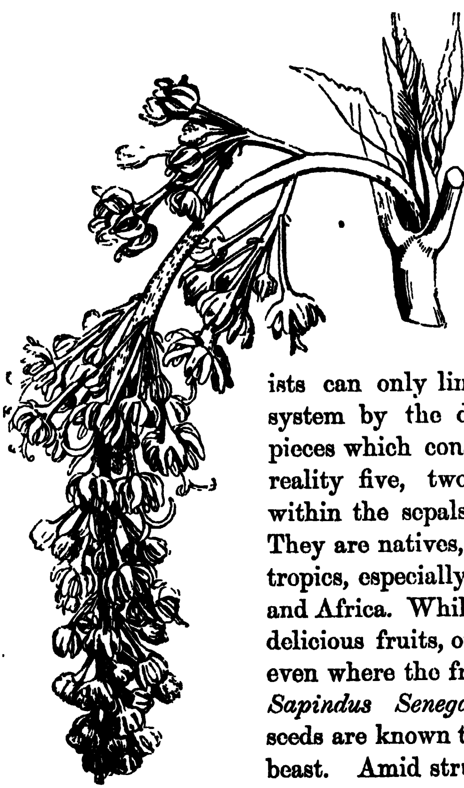


Fig. 396.—Panicle of the Sycamore.

roots of the Sycamore (*Acer pseudo-platanas*) having an abundant

milky fluid in the month of June. The celebrated Snake-root (*Polygala Senega*) is acid and acrid, and acts as a sudorific, and many of them are valuable as febrifuges. Among the Sapindas many of the leaves are poisonous, while the fruits are wholesome and delicious. Different species of *Nephelium* produce fruits of great delicacy in the Indian Archipelago. The roots of the American Horse Chestnut (*Æsculus hippocastanum*), which belongs to this order, are poisonous; and the seeds of the common Horse Chestnut, although they are said to be excellent feed for sheep, are not free from suspicion.

Guttiferales.

Hypogynous exogens with monodichlamydeous flowers; placentæ axile, imbricated calyx, and imbricated or twisted corolla, embryo little or no albumen. The flowers throughout the orders forming the group are symmetrical in their calyx, corolla, and stamens; they are also remarkable for their resinous secretions.

Gigantic exogenous trees, with simple alternate leaves, large convolute stipules, symmetrical flowers, usually large, in racemes, terminal and panicled, or axillary and solitary; equilateral petals, an unequal permanent winged calyx, beaked anthers, and one-celled one-seeded fruit. They are trees of India and the Indian Archipelago, of majestic size and handsome form, with beautiful clustered flowers and richly-coloured winged fruit, bearing some resemblance to the Magnolia in their peculiar rolled-up stipules, and to the oak in its foliage. All the species yield resinous balsams.	CXLI. Dipteraceæ.
Exogenous trees or shrubs, with simple alternate leaves, without stipules, or with very small ones; symmetrical flowers, generally white; equilateral petals; versitale anthers; few or single seed and stigmas on a long style. The greater part of the order are beautiful trees or shrubs of the South American forests, with a few natives of China, India, Africa, and North America.	CXLII. Ternströmiaceæ.
Exogenous trees of large size, with opposite palmate leaves, large symmetrical flowers, arranged in racemes, equilateral petals, sessile stigmas solitary seeds and embryo, with enormous radicle. The order consists of a few large trees of the South American forests in the hottest regions. They yield a delicious nut, and an oil not inferior to that of the Olive.	CXLIII. Rhizobolaceæ.
Exogenous trees and shrubs, with simple opposite leaves, without stipules; numerous symmetrical axillary flowers; equilateral petals; adnate beakless anthers; solitary, or at least few, seeds, and sessile radiating stigmas. All are natives of the tropics, mostly South American, a few of Madagascar and Africa, growing amidst excessive heat and humidity.	CXLIV. Clusiaceæ.
Exogenous trees or shrubs, sometimes climbing and rooting, with simple alternate entire leaves, without stipules; unsymmetrical flowers in umbels, racemes, or terminal spikes; equilateral petals; versatile anthers; sessile stigmas; and innumerable minute seeds. Native of the equinoctial regions of America, with one species belonging to New Caledonia. They are handsome and curious plants, remarkable for their single corollate bracts, adhering by their rooting fibres to the trunks of trees; they are not, however, strictly speaking, parasitical.	CXLV. Marcgraviaceæ.
Herbaceous exogens, sometimes annual plants, shrubs, or trees, with oblique glandular petals, numerous naked seeds, and long distinct styles, having a resinous juice; flowers mostly yellow and regular, with various forms of inflorescence. They are widely disseminated, growing on mountains and valleys, marshes and dry plains, meadows and heath, in Europe, America, Asia, Africa, and Australia.	CXLVI. Hyperiaceæ.
Small exogenous shrubs, with fleshy scale-like leaves, alternate, without stipules, and overspread by resinous sunken glands; oblique glandular petals, a few shaggy seeds, and long distinct styles. They are natives of the shores of the Mediterranean and the salt plains of Northern Asia.	CXLVII. Reaumuriaceæ.

The Clusiaceæ and Guttifers are distinguished for their succulent juicy fruit, in many cases large apples, the Mangosteen (*Garcinia Mangostana*) being the most delicious. They are all plants of the tropics, which Dr. Wight describes as trees of majestic size and handsome form, and deserving of cultivation for the beauty of their clustered flowers, and the richly coloured wings of their curious fruit. The CLUSIACEÆ are chiefly natives of tropical America, a few of Madagascar and Africa, and similar regions where great heat and moisture are combined. Gamboge is the secretion, as is supposed, of *Garcinia cochinchinensis*; and most of them yield balsams and other officinal products.

NYMPHALES.

Hypogynous exogens with dichlamydeous flowers, placentæ axile or sutural, embryo on the outside of a large mass of mealy albumen, but sometimes without. 8 genera, 56 species.

Exogenous herbs, with peltate or cordate fleshy leaves, rising from a prostrate trunk, growing in quiet waters; flowers large, showy, sometimes sweet-scented, a many-celled fruit, and dissepimental placenta. The Water Lilies are floating plants, inhabiting the northern hemisphere, sometimes in South Africa. On the coast of America, they are represented by the Victoria Regia.	CXLVIII. Nymphæceæ.
Exogenous aquatic plants, with floating peltate leaves, axillary flowers, solitary, yellow, or purple; sepals three or four, coloured inside petals; three or four alternate, with sepals; stamens definite or indefinite; anthers continuous with the filament, carpels distinct; abundant albumen; no visible torus. Water-plants of America, from Cayenne to New Jersey, and Australia beyond the tropics.	CXLIX. Cabombaceæ.
Exogenous herbs, with peltate floating leaves, rising from a prostrate trunk, with distinct carpels emerged in a large honeycombed torus without albumen. A beautiful tribe of water-plants, natives of stagnant or quiet waters, in temperate and tropical regions of the northern hemisphere, including the Lotus and Egyptian bean.	CL. Nelumbiaceæ.

The NYMPHALES are floating plants, with peltate or fleshy cordate leaves, arising from the prostrate trunks growing in quiet waters. Their flowers are large, showy, and of bright white, yellow, or blue colours. They inhabit the whole of the northern hemisphere; occasionally they are met with on the South African coast, but generally they are rare in the southern hemisphere. In the South American continent they are represented by the Victoria Lily. Among the *Euryalides*, so named after one of the Gorgons, they have the tube of the calyx adherent to the disc. *E. ferox* is an elegant aquatic, covered with prickles, with peltate orbicular leaves, and bluish purple or violet flowers. This species emulates

Victoria regia in the size of its leaves, with an insignificant flower. The *Victoria regia*, as we have seen in an earlier chapter, produces leaves six feet and a half in diameter, and flowers fifteen inches across. These inhabit the cool translucent lake-like rivers of Demerara, as illustrated in Plate V. The NUPHARDEÆ have calyx and petals both distinct. The species are about twenty. The Blue Water Lily (*N. cærulea*), the sacred plant of the ancient Egyptian, is very fragrant. *N. edulis* contains abundance of starch in its root, and is an article of diet in India. *N. lotus*, the Egyptian Lotus, grows in slow running streams, and in the rice-fields, in Egypt. It has large white flowers, with sepals, red at the margins; the seeds and roots were dried and made into bread by the ancient Egyptians. In *N. alba*, the common White Water Lily of our ponds and ditches, the flowers, according to Linnæus, open in the morning about seven o'clock and close again on the approach of evening. The leaves of Water Lilies are large, succulent, and floating, the sepals and petals numerous, imbricated, and passing gradually into each other, with persistent sepals. The leaf is a rounded ovate, usually purplish beneath, the lobes at the base almost parallel, and the leaf stalk cylindrical. In *Nuphars*, on the contrary, they are ovate, pointed, the basal leaves slightly divergent, and the leaf stalk angular, especially on the upper part.

The NELUMBIACEÆ, or Water-beans, are natives of stagnant waters in the temperate and tropical regions of both hemispheres; chiefly remarkable for the beauty of their flowers. The fruit of *Nelumbrum speciosum* is supposed to have been the Egyptian Bean of Pythagoras, and the flower that mythic lotus so common upon the monuments of Egypt and India.

RANUNCULACEÆ.

Hypogynous exogens, flowers monodichlamydeous, placentæ sutural or axile, embryo minute, enclosed in copious fleshy or horny albumen. 119 genera, 1,703 species.

Fine exogenous trees or shrubs, flowers solitary, often odoriferous, with distinct carpels, large convolute stipules, an imbricated corolla, and homogeneous albumen. The order contains some of the finest trees and shrubs in the world, with strikingly beautiful flowers and foliage; natives of the woods, swamps, and hills of North America, they stretch on the one hand to the West India Islands, on the other to China and Japan.	**CLI. Magnoliaceæ.**

Exogenous trees and shrubs, with distinct carpels, no stipules, a valvate corolla and ruminate albumen; leaves alternate, simple, entire, without stipules; flowers usually green or brown, axillary and solitary. The tropics of the old world are the habitat of the order.	CLII. Anonaceæ.
Exogenous trees, shrubs, or undershrubs, rarely herbaceous plants, flowers in terminal racemes or panicles, often yellow; stamens hypogynous, rising from a torus, carpels distinct, no stipules, imbricated corolla, homogeneous albumen, and arillate seeds. The habitat of the order is Australia, India, and equinoctial America, and in equinoctial Africa a few species are met with.	CLIII. Dilleniaceæ.
Exogenous herbs, rarely shrubs, leaves alternate; dilated petiole nearly clasping the stem; flowers rather conspicuous, with gaily coloured sepals if apetalous, petals hypogynous, distinct carpels, no separate stipules, an imbricated corolla, homogeneous albumen, and seeds without aril. The Crowfoots differ widely in the nature of calyx and corolla, these organs extending into spurs in these organs in Clematis and Larkspurs, while sepals and petals are blended together in Caltha and Anemone, and the spurred and spurless species again assimilated in the Antarctic species, *Ranunculus acaulis*. One-fifth of the order is found in Europe, one-seventh in North America, one-twenty-fifth in India, one-seventeenth in South America, and a few species are found, according to De Candolle, in Australia.	CLIV. Ranunculaceæ.
Exogenous herbaceous perennials, with fibrous roots, inhabiting bogs, leaves radicle, a hollow urn-shaped petiole, a sort of pitcher with articulated laminæ, fitting like a lid; carpels consolidated, with permanent calyx and axile placenta. The singular flower, called the Side-saddle flower, from its tabular leaves, seems to be confined to the bogs of North America, while analogous species inhabit the woods of Guayana.	CLV. Sarraceniaceæ.
Herbaceous, with some shrubby exogens, often with a milky juice, with one, two, or, three-parted flower, consolidated carpels, deciduous, that is, falls off, and generally with parietal placenta; the common red weed of the fields is the well-known example of this order. Two thirds of the order find their habitat in Europe; they range from Siberia to Japan, and a few are American; one genera, Romneya, approaches the Sarraceniaceæ in the structure of its placenta, which divides the ovary with many distinct cells, while the ovules are distributed over the whole surface of the dissepiments, as in the Water Lilies.	CLVI. Papaveraceæ.

Ranals—so called from *rana*, a frog, from many of the species inhabiting humid places usually the haunt of that animal—are characterised by the presence of a distinct calyx and corolla, sometimes so blended together, however, as to be indistinguishable; while in other instances there is no corolla, and occasionally both are absent. In general there is an indefinite number of stamens but there are exceptions to that rule, as in the *Bocagea*, among the Anonaceæ, in which the stamens and carpels are definite.

The MAGNOLIACEÆ include some of the finest trees and shrubs in the world. The typical *Magnolia grandiflora* is an evergreen tree of North America, which sometimes attains the height of seventy feet. Its ovate, oblong coriaceous leaves—the upper surfaces of a pale green, shining and glossy, the under rusty, with white and erect flowers, with nine to twelve expanding petals—constitute it one of the noblest trees of the American forest. There are many species of the genus, of which this is the grandest example.

Other plants of the order are remarkable for the beauty of their flowers. *Liriodendron tulipifera*, the Tulip Tree, with half

a-dozen popular synonyms, is a handsome tree, with four-lobed truncate saddle-shaped leaves, and large elegant flowers, coloured green, yellow, and orange, sometimes attaining the height of a hundred and twenty feet, and a circumference of twenty feet. Nor is the order deficient in officinal properties, or fragrancy. Their general character is bitter and tonic in taste, with fragrant odorous flowers. *M. glania* is so stimulating as to produce fever and inflammatory gout, according to Barton. A species of *Michelea*, called Tsjampar, is the delight of the people of India for its fragrant properties.

The Anonaceæ are trees and shrubs of the tropics in both hemispheres, whence they spread to the north and south within certain limits. Their general properties are their powerful aromatic taste and smell. The flowers of some are sweet and fragrant. Others, as *Anona squamosa*, have a heavy, disagreeable odour. The *Dilleniaceæ* are trees and shrubs of Australia, India, and tropical America, of comparatively little interest, though some of the Indian species are of great beauty. Dr. Wight speaks of them as equally remarkable for the grandeur of their foliage and the magnificence of their flowers. The plants generally are astringent.

The Ranunculaceæ, the typical order of the Ranals, are herbaceous, rarely shrubby, plants, and they are chiefly natives of Europe, with a sprinkling of North American, Indian, and African plants, on the shores of the Mediterranean; acidity, causticity, and poison are the general characteristics of the order, which includes a powerful sudorific in *Ranunculus glacialis*, a strong diuretic in *Aconitum Napellus* and *Cammarum*, drastic purgatives in the *Hellebores*, a virulent poison in some of the seeds of *Aconitum* and *Ranunculus thora*, while many of the order are vermefugal and tonic.

To give any sufficient idea of this important family, it will be necessary to study successively the Columbine, the Hellebore, the Larkspur, Aconite, Ranunculus, Clematis, and Peony. Country people, struck with the form and elegance of the Columbine (*Aquilegia vulgaris*), have bestowed the name of "Our Lady's gloves" upon its flowers (Fig. 397). Its petals are fashioned with spurs, the shape of a hollow cornet, hooked at their extremities; there are five of them, which alternate with as many level

and petaloidal sepals. The stamens are numerous, disposed in ten phalanges, five of which alternate with the petals and five

Fig 397 —The Columbine (*Aquilegia vulgaris*)

with the sepals, which they exceed in length. The whole of the interior face of the anthers is against the filaments, and they per-

form their dehiscence by two lateral clefts. Of these stamens ten only are represented by filaments dilated in the form of membranous scales of a silvery white, folded upon their edges and laid upon the pistil. The organ is composed of five free unilocular ovaries, containing many anatropal ovules inserted in two contiguous vertical series. These ovaries, when at maturity, change into five free follicles. The seeds which they enclose contain a very small embryo, placed at the base of a thorny and very abundant albumen. With regard to the organs of vegetation, the stem is erect, solitary, or more or less numerous,—that is, one only from the head of the roots to the branching on the upper portion. The radicle leaves, for the most part, stalked; base of the stalk dilated leaflets, broad as long, and petiolated with long petiolated divisions of the first order, irregularly three-lobed stem leaves, few with shorter stalks, the upper ones sessile, bracts narrow and three-lobed.

The Columbine (*Aquilegia vulgaris*) is found growing in its primitive simplicity in hilly woods and upon the borders of the forests of Bondy, Montmorency, St. Germain, Versailles, and in woods and copses where the soil is calcareous, in various parts of England and Scotland. In the chalky copses of Kent and Surrey there is no doubt of its being indigenous. In the *Hellebore*, or Christmas Rose, the sepals, five in number, are large, and the petals small and numerous, and situated at the base of the andrœcæum (Fig. 398). The corolla of the Columbine may be said to be a calcareate polypetalous corolla; but culture has worked many curious modifications in the Columbine. We frequently see the five-petalled cornet enclosed with others, fitted in series, whilst five others, of a like series, are placed opposite the sepals. It seems, in fact, as if the flower was entirely composed of these cornets, the one series contained within the other. In other varieties, on the contrary, in place of the hollow spur or cornet, we find only oval and almost flat petals, often in considerable numbers. As in all these cases the stamens become scarce as the supernumerary petals increase in

Fig. 398.—The Columbine. s, five sepals: p, five petals.

number, one is led to think that the formation of these petals arises in some way from the metamorphosis of the stamens.

The HELLEBORES have a calyx with five sepals, a corolla having from five to ten petals, short, tubulous, and bilabiate, an indefinite number of stamens and pistils, varying in number from two to ten. They are slightly coherent at the base; and the ovary, like that of the Columbine, contains two series of ovules. The fruit also is a follicle. To give the reader a better idea of the aspect of plants of this tribe, we will take the Crowfoot (*Helleborus fœtidus*), common enough in stony places by the roadside, and in the glades of forests. It is a plant with a poisonous odour, with thick, generally erect, vertical stem, terminating in a taproot. The stem, which is evergreen during the winter, and ranging from three to six feet in height, is strong and erect, bare in its lower parts, leafy towards the summit, and divided into floriferous branches. The leaves, which adhere to the stem, are coriaceous, and of a spotted green colour, are petiolate, with lanceolated segments, straight, dentate, and generally free at the base. The flowers are inclined, and disposed in branching corymbes. The sepals are concave, erect, and greenish, often edged with purple. The follicles are oblong, and terminate in a long beak or spur.

The Hellebores are all interesting to lovers of gardening, because for the most part they flourish during the winter; such, in particular, are the Black Hellebore, or Christmas Rose, and the little Yellow Hellebore, known to botanists under the name of *Eranthis hiemalis*, which flourishes when the snow begins to fall.

The Larkspurs (*Delphinium*) have a calyx with five unequal petaloid sepals, the upper with straight, pointed, horn-like spur. The petals, which in some species are four in number, in others are reduced to only one by some process of abortion and consolidation, —for originally there are always eight petals, six of which are developed in pairs opposite three of the sepals, while two are developed singly opposite the two other sepals. However that may be, the two superior petals in one case, and the single and superior petal in the other case, are prolonged in a pointed horn included in the spur of the calyx. The stamens, which are very numerous, are disposed in eight series, opposite to the eight original petals: The carpels, from one to five in number, are free, sessile,

and verticilate, changing into follicles at a later period, and occupying the centre of the flower.

The *Delphinium consolida*, commonly known under the name of Wild Larkspur, is frequently found at harvest-time in cultivated fields round Paris, and other places, but in this country it has only been found wild in the Channel Islands. Its stem is slight and straight, with numerous branches, its leaves are slender and thong-like, its short bunches of blue flowers form a panicle. The seeds of this species partake of the acrid and poisonous properties of the genus. The expressed juice of the petals, mixed with alum, make a blue fluid ink. The form of the flower, with the spurred calyx, is represented in Fig. 399.

Fig. 399.—Larkspur (*Delphinium*).

Many beautiful species of the Larkspur are cultivated in gardens, such as the *Delphinium elatum*, *Delphinium grandiflorum*, &c., species originally from Siberia: one of the most elegant is the *Delphinium Ajacis*, originally from the East and from Algeria; it is often met with in gardens, and has also been found in our cornfields, where its seeds have been disseminated, no doubt by some of the aids to nature to which we have alluded elsewhere.

The Aconites (*Aconitum*) have five unequal petaloid sepals, the superior of which is formed like a helmet, or *galla*, lapping over the corolla. This latter organ is composed of from two to eight petals, of which the two upper form an elongated aiglet terminating in a reversed hood; whilst the lower, which are very small and filiform, are often absent altogether. The numerous stamens are disposed in series, as in the Larkspurs, and in the centre of the

flower we find from three to five pistils, which become follicles. The Aconites are very poisonous narcotic herbs, but when applied with discrimination they become eminently useful in medicine, being employed in cases of neuralgia, rheumatism, paralysis, and purulent infections. The most poisonous species is the *Aconitum ferox*, which is acrid in the highest degree. The *Aconitum Napellus* (Fig. 400) is another officinal species; it is rarely met with about Paris, but is often found by tourists in the mountains of Switzerland. On the Jura range it grows to the height of three feet, having straight, simple stems, the upper part slightly branching, furnished with leaves, shiny, of a deep green colour above, and of a pale green below, calyx in five or seven segments, into oblong, incised lobes. Its flowers, which are blue and of an elegant aspect, form elongated bunches, with two little bracts below each flower.

Fig. 400.—Aconitus Napellus.

The *Ranunculus* (Fig. 401) has a green calyx, composed of five sepals; the corolla has five petals, furnished at the internal base of their aiglet with a nectariferous pore at the claw, which is covered by a scale. The stamens and pistils are very numerous; the former are of the ordinary structure, but the latter are disposed in an oblong prolongated globulous head or capitulum, having a short beak, enclosing a single ascending and anatropal ovule, which become achenes after a time. The British species have all white or yellow flowers; and the achenes occur in several rows, forming a globular, ovoid, or oblong head, terminating abruptly in a point. Many of them are submerged or floating plants of slender stem, some of them with handsome showy flowers, sometimes covering the whole surface of the ponds or ditches. This is the case with *R. trichophyllus*, the Water Crowfoot, whose dark green and rather rigid foliage is very conspicuous, and whose leaves,

Fig. 401.—Ranunculus hirsutes

according to Dr. Pulteney (Linn. Trans., v. p. 19), are not only innocuous, but nutritive to cattle, the cottagers on the banks of the Avon gathering them into boats, from which their cows eat them with avidity. Many species of this tribe possess blistering properties, that is to say, they stick to the skin and produce an irritation which goes far towards the destruction of the epidermis, and the formation of a sore: the species used for these purposes are the *Ranunculus flammula* (Lesser Spearwort); *R. lingua* (Great Spearwort); *R. repens* (Creeping Crowfoot, or Golden Crowfoot). When the juice of these flowers is distilled, the liquid drawn from it contains a very acrid principle. Animals will not touch the Ranunculi when fresh, but when dried and used as hay its taste is lost. The Sweet or Wood Crowfoot, *R. auricomus*, or Goldilocks, differs remarkably from most of the tribe; it grows in tufts with numerous stems, very slightly branching above, its habitat, woods, and moist shady places, and it is without the acridity so common to the tribe. The Buttercup, King-cup, or Meadow Crowfoot (*R. enauris*), in spite of its known acridity, has been a favourite with the poets. One sings of

> "The kingcup of gold brimming over with dew,
> To be kissed by a lip just as fresh as its own."

One variety of this species having become double, was a favourite in old gardens, and probably is still, under the name of Bachelors' Buttons.

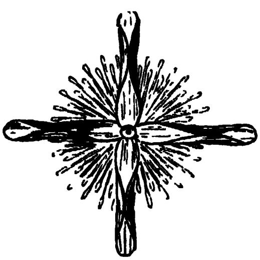
The Creeping Crowfoot (*R. repens*) is the Cuckoo-bud of Shakespeare.

> "When daisies pied and violets blue,
> And cuckoo-buds of yellow hue,
> Do paint the meadows with delight."

Amongst the Ranunculi we must also mention the *Clematis*, *Anemones*, *Hepticas*, and *Adonis*.

The *Clematis* (Traveller's Joy, and several other popular names) has a calyx with four petaloidal divisions, and without a corolla. The stamens and pistils are numerous as in the *Ranunculus;* their pistils are unilocular; after efflorescence they become achenes, with seeds reversed, and surmounted by a sort of plumose tail, resulting

from the growth of the style. They are climbing shrubs. The leaves, when pulled and laid upon the body, produce inflammation, vesication, and ulceration of the skin; properties which mendicants sometimes use to produce artificial ulcers,—hence one of their common names, Beggar's Herb. Its flowers are white, disposed in axillary panicles; the name of "Virgin's Bower" was given to this species by old Gerarde in 1597, "by reason" as he tells us, "of the goodly shadowe which they make with their thick bushing and climing; as also for the beauty of the flowers, and the pleasant savor or scent of the same." And indeed there is no finer ornament in our country hedges, than this pretty bush with its copious clusters of white blossom. The flower has one floral envelope, and is one-cloaked; the corolla is absent, hence the flower is apetalous. Fig. 402 is a front view of the flower, Fig. 403 a back view of the



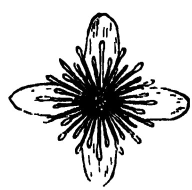


Fig. 402. Fig. 403.
Back and front view of the flower of Clematis *vitalba*.

same flower. We meet sometimes on lawns and gardens with *Clematis flammula* (Sweet Clematis), where it is used to ornament palisades and bowers, and where it is distinguished from the preceding species by its sepals, which are covered with a hairy down at the edges. We frequently see clumps of *Clematis viticella,* where the sepals are violet, purple, or rose colour, the flowers of which are produced double by cultivation. We sometimes see beside this species, the *Atragenum* of the Alps, remarkable for the beauty of its large flowers of violet blue: the *Atragene* tribe is distinguished from the Clematis by the existence of a corolla, composed of numerous petals shorter than the sepals.

Peonies (*Pæonia*) have the calyx foliaceous, coriaceous, persistent, with unequal sepals; the corolla is composed of five, six, or ten

nearly equal petals; the pistils are variable in number, and enclose a great number of ovules; the fruit is a coriaceous follicule; the receptacle is swollen into a fleshy disc, which forms a sort of sack. The seeds are furnished with a slightly developed arill rising out of the placenta which surrounds it. The Peonies are herbaceous or somewhat shrubby perennial plants, with alternate leaves; they are among the earliest ornaments of our gardens in the spring time. In the Moutan Peony, commonly known as the Tree Peony, the petals are sometimes white, marked at the base with a purple shade, and sometimes rose coloured. This Peony has become double under culture; by cultivating this species for fifteen centuries the Chinese have obtained two hundred varieties. The Peony has been introduced into France since the commencement of the present century. We may also note the Common Peony (*Pæonia officinalis*) with red, rose coloured, or variegated petals, the flowers of which are easily grown double. The Peonies were famous as agents of sorcery in the olden times; the Coral Peony is commonly known as the Male Peony.

The Peony has a very ancient history, according to Theophrastus, and after him Pliny; it is to be gathered of necessity in the night, "for if any man shall pluck of the fruit in the day time, being seen of the woodpecker, he is in danger to lose his eyes,"—this is, according to Gerarde, the seeds of the Peony. Even at the present day anodyne necklaces are worn round the necks of children cutting their teeth. It is a common garden plant, and although Withering thought he had found it among the Vincent rocks, on the Avon, near Bristol, growing wild, it was probably introduced there from some foreign country by ships entering the port of Bristol. "Amid the shelving rocks and loose shingly stones, at the elevation of a hundred feet above the river," however, "there ye may see the Peony spreading wide."

PAPAVERACEÆ. The Poppies have a calyx with two caducous sepals, a corolla of four petals, with numerous stamens, provided with a long filament, whose anthers open laterally by two longitudinal clefts. The unilocular pistil is almost entirely divided by many placentary glands, which, emanating from the walls, advance nearly to the centre, bearing a number of anathropal ovules inserted over its whole surface.

The Poppies are herbs with a white milky juice, with dentate leaves; the leaves emanating from the root are petiolate; those issuing from the stem are sessile, or embracing. Their peduncles, solitary, unifloral, are inclined before inflorescence.

We select for description three kinds of Poppy.

1. The Corn Poppy (*Papaver rhæas*) is very common in the corn-fields, cultivated ground, and by road sides, and forms, along with the Corn Centaury, the most graceful ornament, although it is the last plant the farmer would see in his fields; its specific name is derived from Ροια, *pomegranate*, which the capsule is supposed slightly to resemble. (Fig. 404.) Its mucilaginous, acid, bitter petals are emollient and slightly narcotic.

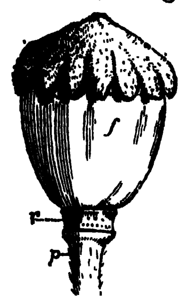


Fig. 404.
Capsule of the Poppy.

2. The Poppy of the East, or Tournefort's Poppy, has scarlet or orange-coloured petals, with black and purple-coloured aiglets; differs but little from the bracteated Poppy (*Papaver bractiatum*).

3. The Narcotic Poppy (*Papaver somniferum*), of which there are two varieties: one, the White Poppy (Fig. 405), so called because the seed is generally white, is the variety cultivated for the purpose of extracting opium; the other is the Black Poppy, because the seed is black, and which furnishes sweet oil, known under the name of Poppy Oil. This oil, in spite of the narcotic influence, is found to be perfectly wholesome, and is extensively used for its own qualities, as well as to adulterate Olive Oil. It is well known that opium is nothing more than the thickened juice of the White Poppy. The juice flows out from an incision made in the ovary a little before ripening.

The history of the Opium Poppy is very obscure as to the date of its first cultivation, but it was well known to the Greeks, and was cultivated for its seeds, as we learn from Theophrastus. It is also described by the Arab authors under the name of "Afeesgou." The White Poppy is supposed to be a native of Asia Minor, or of Persia, but it is nowhere found in a wild state. It is distinguished by obovate or globular capsules, which, as well as the calyx, are smooth; the stem smooth and glaucous; leaves embracing the stem, and incised and obtusely dentate; the flowers are usually red, of

different tints; but there is also a white-flowered variety, which Dr. Royle describes as peculiar to the plains of India, while the red flowers he has only seen in the Himalaya mountains.

Fig. 405.—The Opium Poppy (*Papaver Somniferum*).

The Celandine (*Chelidonium majus*) belongs to the family of *Papaveraceæ*. It is a perennial plant with a reddish yellow juice,

which has a certain reputation for the cure of warts. The stems are straight, branchy, pubescent, being covered with long patulous hairs scattered over it. The leaves have from three to seven lobed oval segments, the lobes notched and crenulate, glaucous below. The flowers, which are yellow, are disposed in simple umbels, differing remarkably from those of the Poppy in the structure of the pistil. This organ, in reality, is composed of a versilocular ovary, having only two parietal placentæ, surmounted by a short style with bilobate stigma. The fruit is a linear capsule, and opens with two valves which detach themselves from the base to the summit; leaves persistent, the frame formed by placentæ.

The seeds seem, besides other remarkable peculiarities, to be provided with a little white cellular excrescence like a crest.

There is still in this family the *Eschscholtzia Californica*, a perennial plant with a large solitary flower of a golden yellow colour, closing itself up when it rains, the sepals of which, coherent at the base, detach themselves in one piece after the fashion of a little pointed hat.

Berberids.

Hypogynous exogens with monodichlamydeous flowers, unsymmetrical in the ovary; placentæ, sutural, parietal, or axile; stamens definite, minute; embryo enclosed in a large quantity of hard fleshy albumen. Seventy-nine genera, six hundred and four species.

Delicate herbaceous exogens, often covered with glands; with regular symmetrical flowers, parietal placentæ, and stamens alternating with the petals, sometimes two, three, or four; the number distinct and withering. The glandular hairs, the irritability of which reaches its maximum in the Catchfly (*Dionæa*), are peculiar characteristics of the order.	CLVII. Droseraceæ.
Herbaceous exogens with brittle stems and a watery juice, having irregular unsymmetrical flowers, purple, white, or yellow; parietal placentæ; stamens opposite the petals; four hypogynous, or six, in two parcels, opposite the outer petals.	CLVIII. Fumariaceæ.
Exogenous shrubs or herbaceous perennials, for the most part hairless, but often spiny with regular symmetrical flowers; sutural placentæ; stamens opposite the petals, and equal in number, with recurved anthers below.	CLIX. Berberidaceæ.
Exogenous scrambling or climbing shrubs, with tumid separate joints, regular symmetrical flowers arranged in thyrses, umbels or panicles; axile placentæ; stamens opposite the petals; anthers opening longitudinally.	CLX. Vitaceæ.
Exogenous trees or shrubs, with regular symmetrical flowers, terminal or axillary; axile and parietal placentæ; stamens alternate, with petals; ascending or horizontal ovules, and imbricated petals. The order are chiefly plants of Australia, a few only occurring in Africa, the Pacific islands, China, Japan, and Madeira; many of them are resinous; some of them yield pleasant sub-acid fruits.	CLXI. Pittosporaceæ.

Exogenous trees or shrubs, often spiny, with regular symmetrical flowers, small axillary, and often fragrant; axile placentæ; stamens alternate with the petals; ovules pendulous, and corolla valvate. A small order of tropical shrubs of Africa Australia, and India, one only of the West Indies, a few of the Cape of Good Hope.	CLXII. Olacaceæ.
Exogenous shrubs, with persistent nonstipulate leaves, with regular symmetrical flowers on racemes; axile placenta; stamens alternate, with the petals equal to them, pendulous ovules; and imbricated corolla. They are natives of North America, with no known useful properties.	CLXIII. Cyrillaceæ.

The Berberid orders do not at first glance present a very obvious or natural arrangement of their respective families. The union of Vines, Fumitories, and Berberis seem at first glance to be paradoxical. But botanists find in their structural anatomy resemblances which are not obvious to the uninitiated. The group is characterised by unsymmetrical flowers, a definite number of stamens, a minute embryo enclosed in a hard horny albumen; but even these characteristics fail in the typical genus Berberis, whose embryo is much larger; but then the long radicle and small cotyledons proclaim a relationship.

Among these plants we have the Droseraceæ, so called from δροσος, "dew," an order of delicate herbaceous plants, chiefly marsh herbs of the south of Europe, and ranging up to the tropics; some of them, as *Dionæa muscipula*, distinguished by the irritability of the leaves when touched by a passing insect, which close upon it suddenly and hold it a fast prisoner. The leaves of the order are usually covered with glands or glandular hairs, the flowers arranged in circinate racemes. Calyx consisting of five sepals; there are five petals, and five to ten stamens; fruit capsular, one-celled, and many minute seeds, having an embryo lying at the base, of abundant albumen. The Sundews, as they are sometimes called, are more remarkable for their singular red-coloured glandular hairs, which discharge a viscid acrid fluid in which insects are caught; than the beauty of their flowers. The British species of the order, which flower about midsummer, are the Grass of Parnassus (*Parnassia palustris*)—growing in boggy places; its large white petals slightly veined,—and three species of *Drosera*, distinguished by their terminal racemose flowers on scapes, and their long reddish glandular viscid hairs. Several of the foreign species have the reputation of being poisonous—*D. communis* to sheep and cattle. *D. lunata* has the viscid leaves and glandular fringes which close upon insects happening to touch them, and is said to yield a

valuable dye. *D. rotundifolia*, the round-leaved Sundew, has the leaves close to the ground, nearly circular, and spreading; with a roundish limb abruptly tapering into a hairy petiole, the stem erect, springing from the centre of the leafy rosette. This plant inhabits boggy places, and is often found near London and elsewhere, along with *Sphagnum*. It is acrid and caustic, and in Italy the liqueur called Rossali is distilled from its juices. It curdles milk, and is said to cure corns and warts. There are about forty species of Drosera found in boggy places all over the world, except in the extremes of heat and cold. Many of them are singularly beautiful. The gaudy *Dionæa*, whose singular irritable leaves greatly resemble the Sundews, is placed in this order by some botanists; its indehiscent fruit and erect œstivation and placenta, placed at the base of a one-celled capsule, are the chief points of difference.

The FUMARIACEÆ, or Fumitories, are herbaceous plants, with slender, brittle stems, and twisting leaf-stalks, yielding a watery juice; their non-stipulate leaves subdivided until their terminal lobes become ovate leaflets; their flowers, two minute ragged sepals, with four exterior petals and six stamens united in two parcels. The leaves of *Fumaria officinalis* are succulent, saline, and bitter, and the expressed juice is recommended in cutaneous and other diseases, to correct acidity. They are named from the French word, *fumer*, to smoke, from the unpleasant smell they all exhale. They are of little interest except to the botanist, to whom their sexual economy becomes an interesting study. The stamens, as we have seen, are in two bundles, the anthers being a little higher than the stigma; "the two middle ones of these anthers," says Dr. Lindley, "are turned outwards, and do not appear to be capable of communicating their pollen to the stigma; the four lateral ones are also naturally turned outwards, but by a twist of their filament their face is presented to the stigma. They are all held firmly together by the cohesion of the tips of the flower, which, never unclosing, offers no apparent means of the pollen being distributed, so as to be shed upon the stigmatic surface. To remedy this inconvenience, the stigma is furnished with two blunt horns, one of which is inserted between and under the cells of the anthers of each parcel, so that, without any change of position on the part of either organ, the mere contraction of the valves of the anthers

is sufficient to shed the pollen upon that spot where it is required to perform the office of fecundation."

The BERBERIDACEÆ, or Barberries, are shrubs, or herbaceous perennials, with pale green, thin, deciduous leaves. Flowers with faint pleasant odour. Fruit and leaves an agreeable acid. Characterised by the anthers opening by reflexed valves, the face of each anther-cell peeling off except at the point of attachment, where it adheres as if hinged. The stamens are opposite the petals; the flowers are usually ternary, there being three or six sepals and a like number of petals and stamens. Anthers two-celled, carpel solitary, free, and one-celled, style rather lateral, stigma orbicular, the stamens and pistil being ranged round it; fruit, a berry, in some species a capsule. The peculiar arrangement and structure of the anthers occur in no other plants except the laurels, and in the latter it is without petals. This structure is well represented in Fig. 406, which represents an anther (*Berberis vulgaris*) in the act of dehiscence, which it accomplishes by the opening of two valves, *v v*, from which the pollen is shed in the form of fine dust, *p*. This process is said to be dehiscence by two valves, one in each lobe. The bushes or herbs of which this order consists are extremely dissimilar in habits and appearance. They belong to the temperate parts of the world, being unknown in the tropics, except on mountain ranges. The common Barberry (*Berberis communis*), so called from βερβερυ, the Greek name of the fruit, is well known from its pleasant acid flavour; glands upon its petals and pinnate leaves,

Fig. 406.


Fig. 407.—Stem of the Barberry.

the leaflets reduced to one, and the primary leaves to spines. The spiny leaves and stem are well represented in Fig. 407, which shows the palmate or tri-partite spiny leaves, in the axils of which buds are developed bearing true leaves; others become indurated sharp-pointed axes or spines. It is also remarkable for the irritability of its stamens; these, when the filament is touched on the inside with the point of a pin in dry weather, bend forward towards the pistil, touch the stigma with the anther, and remain curved for a short time, and then partially resume their erect position. In wet weather, when the filaments have lost their elasticity, the phenomenon is scarcely perceptible. The same result attended the experiment of applying arsenic or corrosive sublimate to the filaments; they became rigid and brittle, and lost their irritability. On the other hand, on the application of narcotics, as prussic acid or belladona, the irritability was destroyed by the filament becoming flaccid and relaxed.

The Barberries are interesting from their graceful elegance, both in their racemes of yellow flowers and rather ovate delicate berries. Their bark and root are used for dying leather and linen of a yellow colour. Several Indian species have similar properties, and the acid quality of its fruit has long placed it among the favourite febrifuges, but it may be doubted if it has any quality beyond the refreshing flavour it imparts to water.

Botanists have divided them into :—

True Barberries.	I. Thin, simple leaves, solitary flowers, deciduous.	B. Siberica.
	II. Thin leaves, mostly deciduous flowers in racemes.	B. Cretina. B. Vulgaris. B. Canadensis. B. Cratagina. B. Iberica. B. Sinensis.
	III. Leaves leathery; evergreen; flowers solitary or in clusters.	B. Wallichiana. B. Dulcis. B. Heterophylla. B. Empetrifolia.
	IV. Leaves leathery; evergreen; flowers in racemes.	B. Floribunda. B. Asiatica. B. Dealbata. B. Aristata.
Ash Barberries.	Leaves pinnated; all evergreens	B. Fascicularis. B. Aquifolia. B. Repens. B. Glumaceæ.

Besides these, several species remain unclassed, as *B. Leschenaultii'* a fine pinnated shrub of the Neilgherry mountains, with a black round fruit; *B. Nepalensis,* which grows twelve feet high at six

thousand feet above the sea; *B. tragacanthoïdes*, with one or two pairs of leaflets, and the points of the leaves hardened into spines, is found on the banks of the Kur, near Tiflis.

Farmers in England have an idea that the proximity of the Barberry to wheat-fields interferes with their crops. It is difficult to imagine why, unless the *Æcidium berberidis*, the fungus which is known to infest it, acts injuriously on the wheat crop, producing rust or mildew.

The VITACEÆ, or Vine tribes, consist of sarmentose and climbing shrubs, that is, with filiform twining runners; the Grape being the type of the order, which Kunth names *Ampelideæ*, from ἄμπελος, the vine; and Jussieu, *Vites*, from *vitis*, a vine. The order has acid properties, in common with Grossulaceæ and Berberaceæ, and includes six genera, which are for the most part found in the temperate zone of both hemispheres. Like all extensively cultivated plants, the native country of the Vine (*Vitis venifera*) is doubtful. It is among the plants spoken of in the Books of Moses, when the Vine appears to have been used as it is in the present day. From this circumstance, there is little doubt of its being truly indigenous in Asia between the Black Sea and the Caspian—of Mount Ararat and of the Taurus. In the forests of Mongrelia and Imeretia it flourishes in great magnificence, climbing to the tops of the highest trees, bearing bunches of fruit of delicious flavour. The Vine is found growing wild in many parts of France and Germany, and as far north as the 55th parallel, and also all over the south of Europe and Asia Minor, and southern latitudes as high as 40°, but it may be doubted if it is indigenous in any part of Europe.

The Sabean farm, of which Horace said,

> "Angulus iste feret piper et thusocyus uva,"

is altogether changed, for vines hang in festoons from tree to tree over the site of his abode, supposing Mr. George Dennis is correct in placing the farm in the valley of the Digentia, and the Fons Bandusiæ in the narrow glen which opens just beyond it.

In Middle Germany the Vine ceases to grow at 1,500 feet above the level of the sea; south of the Alps it reaches 2,000 feet; on the Apennines and in Sicily it grows at 5,000 feet, and in the Hima-

layas it reaches 10,000 feet above the level of the Indian Ocean. In England the Vine was probably introduced by the Romans, for there are indications that vineyards were planted in the third century by the Emperor Proteus, which still existed in the eighth century, according to the Venerable Bede. William of Malmesbury, writing in the twelfth century, commends the vineyards of Gloucestershire; and we have read somewhere that the remains of vineyards are not unusual in the south and west of England. But these must also be considered as indications of a changing climate, for although recent attempts have been made, on the system of cultivation introduced by Hoare, to establish vineyards of considerable magnitude in Wiltshire and elsewhere, we are not aware that they have prospered. This arises from the shortness of our summers. England has a mean temperature as high as that of many countries where the Vine flourishes in perfection, but there is a want of heat and sun in the months of September and October, at which time the Vine is ripening its fruit.

The fruit of the Vine is a grateful article of diet in various conditions. As fresh grapes its smell and flavour is delicious. Muscatel grapes, dried, which is effected by cutting half through the footstalk while suspended from the tree, form one of our finest dried fruits; and currants, or corinths, are the dried fruit of a Vine which grows in Zante and Cephalonia.

Now, what are the characteristics and organisation of the Vitaceæ?

The leaves are cordiform: that is, they are slightly heart-shaped, having two rounded lobes at the base; it throws out tendrils, or branches, borne at the point of insertion of the leaves, by the aid of which it creeps along the object on which it is placed. The flowers of the Vine are disposed in a multifloral panicle, very small and greenish, with a sweet odour, which in spring perfumes the fields in the south of France, where this shrub is cultivated over an immense surface. The panicle of flowers, with the cordate leaf, are well displayed in Fig. 408.

The calyx is small and very short, with entire or toothed margin, and is composed of the corolla, with four or five petals, scarcely perceptible, inserted on the summit of the disc, turning inwards at the edge in æstivation in a somewhat valvate manner, the apex

often inflexed. To the petals are opposed four or five stamens, with free filaments cohering slightly at the base, having bilocular anthers opening from within by two longitudinal clefts, and attached dorsally. From the centre of the flower rises a free ovary, surrounded at the base by a glandular disc, which is surmounted by a simple stigma, sessile and flat at the summit. This ovary is superior, and two-celled, each cell enclosing two collateral anatropal ovules, ascending from the base of the chamber. Each of these ovules becomes a globular berry, as in Fig. 409, which contains, when it does not prove abortive, four seeds or pips. These seeds, the shells of which are horny, enclose a very small embryo, erect in the direct axis of a very abundant fleshy albumen.

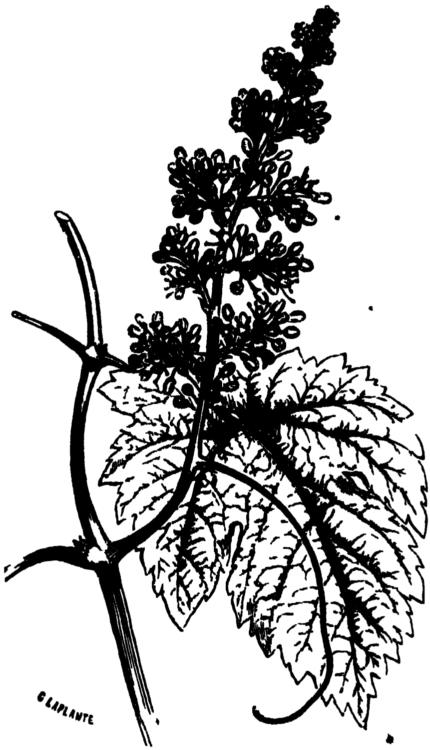


Fig. 408.—Flower of the Vine.

Under the general name of wine is designated the juice of the grape when it has been subjected to fermentation, and we need not trouble ourselves to express here how important the grape harvest becomes to many countries. In France nearly five millions of acres are planted with vines, and if these produce in average years two thousand millions of vines of all qualities, it shows that the culture of the Vine is perfectly suited to the temperate climate of the country.

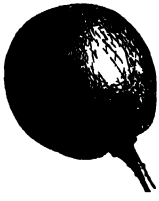


Fig. 409.—Vine Berry.

We have already stated that the forests of Mongrelia and the

mountains of the Caucasus are the native country of the Vine; the actual limits of cultivation in Europe have been more exactly defined in the "Atlas de Physique Végétale" of M. H. Tricholet, who devotes a map to the limits of vine culture on the globe. In this map a red line, drawn from Cape Finisterre along the coast of Spain, across France, leaving Paris a little to the north, across Germany, the northern shores of the Black Sea, to the Caucasus and Caspian Sea, forms the northern limits of cultivation for wine; the Mediterranean, the Sea of Marmora, and the southern shores of the Black Sea, being its southern limits. A bold dash of green colour, which covers the whole of the western hemisphere, from 30° south latitude to the parallel of New York and the west coast of Africa, indicates the range of the wild grape; while a delicate yellow tint, extending over a great part of Arabia, Asia Minor, and south and east of the Caspian, as far as China and the seas of Japan, marks the range of country over which the grape is cultivated for its fruit only, either dried or in its green state.

The Vine requires a temperate climate, but its prosperity depends, not upon the mean temperature of the country, so much as upon the heat and length of summer. The heat should be sufficiently intense to ripen the fruit; and this requires that it should endure far into the autumn in order to ripen the grapes.

There are from twelve to fifteen species of the Vine, but the varieties produced by cultivation and cross impregnation are innumerable. Greater differences are the result of soil and situation; gentle sloping hills, well isolated, with a south and westerly aspect, upon which the sun's rays rest the whole day, are the best localities; and the influence of temperature is such that it is quite usual to obtain upon the same hill grapes of the most opposite qualities, according to the variable heights. As to the influence which the composition of the soil exercises, it appears to be more a question of bouquet than of quality in the wine. In short, excellent wines are produced from soils of the most opposite quality. The best *crus* of Burgundy are the produce of an argillaceous chalky soil; those of Champagne proceed from a soil eminently calcareous. The vines of the Hermitage ripen

their fruits upon the crumbling *débris* of granitic rocks; those of Chateauneuf upon a siliceous soil. An unctuous sandy soil produces the wines of Graves and Medoc; while a schistose soil produces the wines of Lamalgue, near Toulon.

It is very important to choose the suitable pasture on which to feed the Vine, which is essentially a coarse-feeding plant. Soils which are too energetic produce quantity at the expense of quality. Where the grape is high-flavoured, it alters the aroma of the wine. The nourishment most appropriate to the vine is without smell and of slow decomposition, such as woollen rags, clippings of horn, and such refuse. Its own ashes constitute an excellent manure, restoring to the vine the salts of potash which were drawn from it in the previous year's growth.

The composition of the grape is sufficiently complex. It consists of the following substances, viz.: water, lignine, saccharine, pectine, tannin, albumen, the germs of fermentation, in azote, essential oils, glycerine, colouring matter (yellow, blue, and red, the first occurring only in white grapes), fatty matter, salts of lime and of potash—viz. pectin and tartrates—oxides of iron and silica. Amongst these various substances the saccharine matter, or *glycose*, which produces alcohol by its fermentation or chemical decomposition, plays the most important part in the act of converting the juice of the grape into wine.

It is only when the grape is thoroughly ripe that the vintage should take place, if it is desired to have wine of good quality. Where the properties are enclosed, perfect ripening can be waited for; but in most vineyards of France the harvest is pushed on by the *ban de vendange*, which is fixed by the local authorities acting under a council of vine-dressers.

The various operations which follow the vintage are reduced to four. 1. Fullage of the grapes. 2. Fermentation of the *must*. 3. Decuivage. 4. Pressurage.

Fullage is the art of dividing and crushing the fruit; exposing the juice momentarily to the action of the air and bringing the fermenting principle into contact with the saccharine matters. Formerly the operation of crushing the grapes was performed by the vine-dresser stamping upon them with the feet; now the grapes are crushed at a price proportioned to the vintage by

passing them between two cylinders, channeled, and turning in inverse directions.

When the grapes are crushed effectually, they are abandoned to fermentation. In proportion as fermentation advances, the temperature of the mass increases, so that it sometimes attains the temperature of 50° C. It originates much carbonic acid gas, which brings to the surface parts of the stem and husk of the grape, and forms a thick sort of covering to the liquid mass, which is called the *chapeau*. The fermentation, which is well developed on the second day's Encuivage, is continued up to the eighth day, its state being indicated by the gas ceasing to be disengaged, and by the colour of the liquid, which takes a fine vinous tint, the alcohol, which is now present, having dissolved the colouring matter contained in the pellicles of the grape.

When Decuivage is about to take place, the liquor is drawn off, by means of a tap at the bottom of the vat, into casks, which are filled only to the fourth or fifth of their capacity, and which are then left open, in order that fermentation may continue slowly and the disengagement of gas still proceed.

The mass of the vintage remaining in the tun after the liquor is drawn off, is subjected to pressure. The liquor which flows under this pressure, however, cannot be wine of equal quality. This is the process by which red champagne is produced.

White wine can always be obtained from red grapes. To effect this, in place of leaving the must to ferment with its residuum of husk, the liquor is drawn off as it is pressed, and fermented in separate tuns. As the colouring matter of the wine only exists in the pellicle of the grape, we can readily conceive that, being separated at once from the must, little or no colour is communicated to the liquid.

The wine preserved in the tuns, as we have said, ferments slowly by this second fermentary process, the liquid is clarified, the foreign matter is deposited, and forms the lees, which accumulate at the bottom of the tun. In order that the wine may retain its good quality, it becomes necessary to draw it off; that is, to separate it from the lees. In the months of March and April the wine is thus drawn off. If it is not quite limpid, recourse is had to clarification, or Collage. This operation is intended

to make the wine pure and limpid, and divest it of the fermenting principle which is still held in suspension, and which might produce renewed fermentation. The fining for red wine is made of white of eggs, of blood, or of gelatine. The albumen or gelatine of these substances combining with the tannin dissolved in the wine, forms a precipitate, that is, a substance insoluble in the liquid, which is slowly deposited in the bottom of the tun, drawing with it all other foreign substances held in suspension in the liquor.

The sparkling wines of Champagne are prepared by special processes which require more particular description. The greater part of these wines are made from the red or purple grape, the juice of which is generally richer in saccharine than the white. A first pressure of the grape yields the liquor which produces the whitest wine. The residuum being subjected to further pressure, furnishes the juice which gives the rose-coloured wines. The *must*, white or rosy, is then put into great tuns, in which fermentation is established. After twenty-four hours the must or wort is drawn from the tun into another, which is filled and closed. This wine is drawn and fined three times, at intervals of a month, and in the month of April it is bottled. At this time three to five per cent. of crystallised or candied sugar is added to the liquid. At the end of a few months this added saccharine produces fermentation in the bottle, which increases the richness of the wine in alcohol and carbonic acid gas. In consequence of the excess of gas thus evolved, the bottles ought to be well corked, and the corks strongly secured with iron wire. The sugar added in bottling tests the alcoholic strength of the liquor and rouses the fermenting material remaining unconsumed in the wine, and the carbonic gas evolved in the renewed process having no means of escape, mingles with the wine, and renders it effervescing.

The pressure of the carbonic acid has the effect of bursting about twenty or thirty per cent. of the number bottled; the consequence has been a special manufacture of bottles for the wines of Champagne, many of the manufacturers supplying bottles under a warrantry that they will support a pressure of fifteen

The bottles remain full, and are placed in horizontal beds, for six months without being disturbed. But during this period fermentation has produced in the bosom of the liquor a deposit which proves clearly enough that fermentation has been going on. It is necessary to remove this deposit, which would otherwise destroy the transparency of the liquid. This new operation, which is called disgorging (*dégorgeage*), is one of extreme delicacy. The operator shakes the bottle so as to detach the deposit from it, and replaces it gently in a vertical position, the mouth downwards. The deposit thus descends to the neck of the bottle; if it is rapidly uncorked in that position the pressure of the liquor expels the deposit. The great delicacy of this operation lies in the necessity of losing the least possible quantity of gas and wine. The Champagne cellarman performs the difficult operation with great address.

The Liqueurs of the Vine are those which after fermentation preserve a great part of their saccharine. It is chiefly in the countries of the south of Europe—in Italy, Spain, and the south of France—that these wines are prepared. To obtain Tokay, for example, the proportion of saccharine is increased by leaving the most choice grapes to get thoroughly ripe, even to the extent of being slightly touched with frost; and even by placing them, after being cut, upon frames to dry, in order that the water may evaporate in part, thus increasing the saccharine richness of the must.

It is thus apparent that in vinification the chemical process is not confined to the conversion of sugar into alcohol. There are besides the combinations between the various free acids and the alcohol, with the essential oils proper to the kind of grape which produce what is called *bouquet* in wines. Their alcoholic richness is also very variable, as the following table of the natural strength of wines will show:—

Port or Madeira	20	per cent.	of alcohol.
Sherry, or Lachryma-Christo . . .	17	"	"
Old Madeira	16	"	"
Malaga and White Sauterne . . .	15	"	"
Vin de Baume	12·2	"	"
Valney, Rhine Wine, and Fontignan	11	"	"
Tokay	9·1	"	"

It is alcohol which gives to wines their intoxicating quality. Tannin gives them roughness. This roughness is corrected by many finings, which withdraws a portion of the tannin in combination with the albumen or gelatine employed. The acids are acetic acid and the tartaric acid of potassium, or cream of tartar, which give to wine its tartness; and this acidity is corrected by adding a suitable quantity of neutral tartrate of potash, which forms with the acetate of potash and bitartrate of potash a salt imperfectly soluble, which deposits itself in great part in a crystallised state. As the cream of tartar is gradually deposited in the tuns or in bottles, it follows that the wines in time lose much of their acidity. In *aging* they lose also much of their colouring matter and take the tint which is called *pelure d' Oignon* in France.

The PITTOSPORACEÆ are chiefly trees or shrubs of Australia, Africa, New Zealand, Norfolk Island, China, Japan, and the adjacent islands. The berries of *Billardiera mutabilis* are eatable; the fruit is green and cylindrical, becoming a pale amber colour when ripe.

The *Olacaceæ*, trees or shrubs, often spiny, are a small order consisting of tropical or hardy tropical shrubs of the East Indies, New Holland, and Africa, with one of the West Indies, and a few of the Cape of Good Hope.

The *Cyrillaceæ* are evergreen shrubs, with simple non-stipulate leaves, all inhabitants of North Ameriea, and of little general interest.

The EUDRYALS have been formed into a group of which Mr. Myers has published a monograph. They consist of Icacinaceæ, evergreen trees and shrubs, formerly confounded with Olacaceæ, from which however they differ in the calyx being always small, persistent, unchanging, and never enlarging with the growth of the fruit; the stamens always alternate with the petals never-opposite; flowers symmetrical, articulated on their pedicels; consolidated carpels, and axile placentæ. The group consists of evergreen trees and shrubs, natives of tropical or nearly tropical countries, chiefly Africa, the East Indies, America, and Australia.

ERICETALS.

Hypogynous exogens, with dichlamydeous flowers, symmetrical in the ovary, placentæ axile, stamens definite, embryo enclosed in copious fleshy albumen, stamens sometimes adhering to the corolla. Eighty-nine genera, one thousand two hundred and fifteen species, including *Andromeda*, dangerously acrid; *Ledum*, *Kalmia*, and *Azalea*, narcotic and dangerous; *Rhododendron*, oily and narcotic; *Arbutus*, fruit narcotic, bark and leaves astringent.

Exogenous trees and shrubs, with polypetalous flowers, in terminal racemes or corymbs; perfect monodelphous stamens; two-celled anthers, with a long membranous connective; leaves alternate, simple, without stipules.	CLXIV. Humiriaceæ.
Exogenous shrubs or small trees, remarkable for the great beauty of their monopetalous flowers of white or purple, borne in spikes, racemes, or solitary; perfect free stamens; seeds with a hard skin; and one-celled anthers, opening longitudinally; leaves alternate, usually stalked, their base sometimes overlapping and half sheathing the stem.	CLXV. Epacridaceæ.
Herbaceous exogens, rarely undershrubs, with stems round, naked, but leafy in the fruit-bearing species; half monopetalous flowers in terminal racemes or solitary; the stamens free and perfect; loose-skinned seeds; and an embryo at the base of albumen.	CLXVI. Pyrolaceæ.
Stemless herbaceous exogens, with lobed or pinnated leaves, without stipules; scape-like stems, with polypetalous flowers; the stamens free, half sessile, half scale-like, and four times the number of the petals; minute embryo at the base of a fleshy albumen. All the known species belong to Chili.	CLXVII. Francoaceæ.
Parasitic exogens growing on the roots of other trees, the stems brown or colourless, without leaves, but covered with scales, having half monopetalous flowers, in terminal spikes or racemes; free stamens, all perfect; loose-skinned or winged seeds; and an embryo at the apex of the albumen: dehiscent anthers, and the position of the embryo distinguishes them from the Pyrolaceæ.	CLXVIII. Monotropaceæ.
Exogenous shrubs or under-shrubs, with evergreen leaves, entire, whorled, or opposite anthers, stipules rigid, monopetalous flowers, free definite stamens, all perfect, loose-skinned or tight-skinned seeds, and two-celled anthers opening by pores.	CLXIX. Ericaceæ.

ERICETAL plants, from ερικω, "I break," have dichlamydeous flowers, symmetrical in the ovary, axile placenta, definite stamens, and embryo enclosed in a large fleshy albumen; having polypetalous flowers in Humiriaceæ and Francoaceæ, monopetalous in Epacrids and Ericaceæ, and half monopetalous in Pyrolaceæ and Monotropaceæ.

The HUMIRIACEÆ are trees or shrubs yielding a balsamic juice, all natives of the tropical parts of America. The balsam yielded by *Humirium floribundum* is a yellow liquid, called Balsam of Unciri, resembling Copaiva and Balsam of Peru.

The EPACRIDACEÆ, from επι, "upon," and ακρος, "the top," in reference to its habitat on hill tops, are small trees and shrubs, remarkable for the great beauty of their flowers and the singular structure of their leaves, which are alternate, rarely opposite,

stalked, and sometimes entire or serrated, dilated at their base, overlapping each other and half sheathing their stem, without a midrib, but with veins radiating from the base. The flowers, generally monopetalous, are white or purple, borne in spikes or terminal racemes; but not unfrequently the corolla is divided, giving them a polypetalous appearance. All the fruit-bearing section, such as the Australian Cranberries (*Lissantha sapida*), are esculent, but the seeds are large and the pulpy covering too thin to be available for food. The Tasmanian Cranberry (*Astroloma humifusum*) is found all over that colony; the fruit, generally greenish white in hue, is sometimes slightly red, and about the size of a Black Currant, consisting of a viscid pulp, apple-flavoured, and enclosing a large seed. It grows singly on a trailing stem. The native Currant (*Leucopodium Richei*) is a large, densely foliaged shrub, growing on the sea-coast to the height of seven feet; the berries small, white, and of a herby flavour. A French naturalist, named Riche, who accompanied the expedition in search of La Perouse, was lost for three days on the south coast of Australia, and supported himself chiefly upon the berries of this plant.

The genus *Epacris* scarcely differ from the small-leaved genera of Ericetals either in habit or character, except that in the former the anthers are two-celled. Dr. Brown was the founder of the order, and his reason was that the family of the Ericaceæ is now so vast that it seems to constitute a class rather than an order. "I may therefore," he says, "be allowed to propose another order, Epacrideæ, which is truly natural, although it depends upon the single character of the unusual simplicity of the anthers—a character, however, which is of the greater value as being opposed to the two-celled anthers of Ericeæ, which are generally divided and furnished with appendages. The propriety of the measure is moreover confirmed, not only by the number of Epacrideæ, large as it is, but also by their geographical position, for all, as far as we know them at present, are inhabitants of Australia and Polynesia—countries in which not more than one or two species of Ericeæ are found."

The *Pyrolaceæ*, *Francoaceæ*, and *Monotropaceæ*, though placed by botanists among the group of Heaths, differ very widely from them.

The ERICACEÆ or Heaths (Fig. 410), are small trees, shrubs, or under-shrubs, with rigid evergreen leaves, whorled or opposite, and without stipules. Some few species are natives of Europe; several of the genera, such as the Heaths, Lings, Azaleas, Andromeda, and Arbutus, having representatives in the British Flora. But the country of the Heaths is the Cape of Good Hope, where immense tracts of country are covered with them. *Erica cinerea* and *Calluna vulgaris* abound in central France, and round Paris. The Tree Heath (*Erica arborea*) belongs to the region of the Mediterranean, overshading all other Heaths by its height, which sometimes reaches to sixteen or eighteen feet. Its flowers are numerous, and their sweet odour diffuses itself to a great distance. The Broom Heath (*Erica scoparia*), which is found in the North, West, and South, takes its name from the humble use to which it is applied; it grows in woods, and in sterile and uncultivated lands.

The Heaths have regular flowers; the calyx is monosepalous, and divided into four parts, the separation being generally slight; the corolla varies in form, from globulous or pitcher-shape, to tubular, bell, or rather patera-shaped, presenting four lobes alternating with the divisions of the calyx. The corolla does not, as is usual, carry the eight stamens which compose the andræcæum; these are inserted upon the receptacle. The pistil is composed of a superior ovary surmounted by a very erect style, and a stigma in the form of a cup. The ovary is four-celled, and in the internal angle of the placenta the fruit is placed, charged with anatropal ovules. The fruit is capsular, opening dorsally. The seeds are oval, reticulated, having an erect embryo in a fleshy albumen.


Fig. 410.—Heath blossom.

Along with the Epacrids and Heaths, are ranged the Azaleas, Kalmias, and Rhododendrons, producing flowers unequalled for their beauty in the whole vegetable world. For richness of colouring, elegance and variety of form, delicacy of texture, and minute microscopic perfection of corolla, the Heaths stand

unrivalled. Even the wild Moorland Heath of our mountains, although ranking among the lowliest of their race, are, for their beauty, objects worthy of the closest examination. In the Northern parts of the island, Heather or Ling (*Calluna vulgaris*), mingling with other species, cover vast tracts of country, mingling their hues of purple, red, and pink, with the most brilliant effect. A cultivated variety of this species, with double flowers, is extremely beautiful, and the flowers of *Erica carnea* are the earliest harbingers of spring.

The Strawberry-tree (*Arbutus unedo*), whose ripe red fruit of the past year is borne at Christmas-time on the same branch which supports the drooping panicled cluster of flowers of the present, is one of the most agreeable objects in nature.

The trailing *Azalea procumbens* of the Scottish mountains, with leafy branches, tortuous stem, and small elliptical leaves with revolute margins, five-parted purple calyx, and bell-shaped corolla, is a pleasing object on the hill-side; but in the Western hemisphere, ranging from Canada to Georgia, it is a shrub three to twenty feet high, and of exquisite beauty, mingling its foliage with the shrubby leaves of *A. vircora*, green on both sides, and fringed at the edge with deliciously fragrant whitish tubular flowers, or, from New York to Virginia, with the small dark-green shining leaves of *A. nitida*, hairy on the midrib and the margin, and reddish-white tubular flowers. The American species seem to culminate in *A. arborescens*, described by Pursch as a beautiful species rising from ten to twenty feet, which grows on rivulets near the Blue Mountains, in Pennsylvania, forming with its elegant foliage and large abundant rose-coloured flowers, the finest ornamental shrub with which he was acquainted.

The Indian and Chinese Azaleas (*A. sinensis*) approach nearer to the Rhododendrons, having downy leaves, flowers with silky petals, leaves glaucous underneath, bell-shaped corolla with segments broadly ovate, wavy, and the upper one dotted after the manner of the Rhododendron. *A. Indica* again, forms a bush two to six feet high, with drooping branches, leaves deep brownish green, and half evergreen, with large showy and brilliantly-marked flowers.

But these native plants sink into insignificance when compared with the gorgeous specimens which are produced in hundreds

at our flower shows; pyramids, domes, and clusters are there presented, with flowers of every hue, in such profusion as to be almost oppressive, and one sighs for a glimpse of native heath as a relief from the gorgeous picture, though it should be but a hill-side covered with *Calluna vulgaris*.

Rhododendrons differ from Heaths chiefly in having ten instead of five stamens, in the bell-shaped corolla, and in the foliage being hard and evergreen. The first of the species introduced seems to have been from Asia Minor, whence *R. ponticum* was obtained; but the species introduced from the Sikhan Himalayas, excel all others in beauty, and variety of form and colour. The various species are too well known to justify our entering on further description here.

The Kalmias are evergreen shrubs, with a small five-leaved calyx, cup-shaped corolla with angular open limb, and a five-celled and many-seeded capsule; when in blossom their elegant striated petals give them a beautiful appearance, but they are said to be poisonous. *K. latifolia* yields a nectarous juice eagerly sought after by bees and wasps, but the honey secreted from the juice is said to be poisonous; and the juice which exudes from the flowers is said to have dangerously intoxicating properties.

Rutaceals.

Polypetalous exogens, having monodichlamydeous symmetrical flowers, axial placentæ, imbricated calyx and corolla, definite stamens, and embryo with little or no albumen. By the older botanists the Rutaceals were all considered as one order. De Jussieu places them among his dicotyledonous hypogens, which have the stamens inserted upon the receptacle under the ovary. Dr. Lindley divides the group into thirteen natural orders, as follows:—

Trees and shrubs, bark almost smooth, and filled everywhere with little transparent receptacles for volatile oils; succulent indehiscent fruit, leaves dotted, alternate, often compound, articulated with the petiolar petals and stamens; three and five, equal or double of the latter. Including oranges, lemons, and shaddocks.	CLXX. Aurantiaceæ.
Trees or shrubs abounding in balsam, with alternate or opposite and dotted leaves; axillary terminal flowers in racemes or panicles; petals valvate, three to five; stamens twice the number; fruit hard, dry and valvular.	CLXXI. Amyridaceæ
Timber trees, with alternate pinnate leaves, without stipules; flowers in panicles; petals, four or five; stamens free or monodelphous; double in number; capsular fruit; seeds winged; numerous.	CLXXII. Cedrelaceæ.
Trees or shrubs, with leaves, dotted alternate, sometimes opposite; non-stipulate flowers in loose masses; sometimes imperfect by abortion; fruit, berried or capsular; stamens monodelphous; seeds wingless.	CLXXIII. Meliaceæ.

Trees or shrubby exogens, with alternate simple or unequally pinnate leaves; terminal axillary flowers with bracts; apocarpous fruit; and a single ovule rising from the base of the cell.	CLXXIV. Anacardiaceæ.
Trees or shrubby, sometimes climbing exogens, with compound leaves; terminal or axillary flowers in racemes or panicles; apocarpal fruit, and ascending orthotropal ovules.	CLXXV. Connaraceæ.
Trees or shrubby exogens, rarely herbaceous plants; leaves non-stipulate, opposite, or alternate, covered with pellucid resinous dots; axillary or terminal flowers; fruit few-seeded, becoming anacarpous; pericarp separating into two layers; sessile pendulous ovules, and unisexual flowers.	CLXXVI. Rutaceæ.
Trees or shrubby exogens, with non-stipulate, alternate, or opposite leaves: flowers axillary or terminal; fruit few-seeded, becoming anacarpous; pericarp separating into layers; sessile pendulous ovules.	CLXXVII. Xanthroxylaceæ.
Smooth trees or under-shrubs; leaves alternate, simple, or toothed, with two stipules at the base or one at the axil; flowers in racemes; fruit one-seeded, becoming apocarpous; and a succulent conical torus.	CLXXVIII. Ochnaceæ.
Trees or shrubs, leaves alternate, compound, sometimes simple, without stipules; peduncles axillary, few-seeded fruit, becoming anacarpous.	CLXXIX. Simarubaceæ.
Trees, shrubs, or herbaceous exogens, with opposite stipulate leaves, usually unequally pinnate; flowers solitary, in pairs or threes; hermaphrodite; fruit few-seeded, finally anacarpous; torus dry and microscopic; seed albuminous.	CLXXX. Xygophyllaceæ.
Small annual exogens, with opposite leaves; stipules between the petioles; polypetalous flowers, and many-seeded anacarpous fruit.	CLXXXI. Elatinaceæ.
Herbaceous exogens, with capillary leaves, axillary or terminal, very imperfect flowers; many-seeded anacarpous fruit.	CLXXXII. Podostemaceæ.

The group of exogens of which the well-known and humble Rue is the type, includes the Orange, the Melon, the Lime, the Shaddock, Forbidden Fruit, and the Citron in the *Aurantiaceæ;* incense-yielding trees or shrubs in the *Amyridaceæ;* a substitute for Peruvian Bark, is the Bastard Cedars, in *Cedrelaceæ.* The *Anacardiaceæ* include the Cashews. *Pistachia vera,* a tree fifteen feet high, originally from Syria, yields the fruit so much esteemed as the Desert Nut. Gum mastic is drawn from *P. lentiscus.* The aromatic bark of *Rhus cotinus* (the Wild Olive, or Sumach) is one of the substitutes for Peruvian bark. The order generally yields resinous products of considerable commercial value. The *Rutaceæ* agree with the Aurantiaceæ in having dotted leaves, definite stamens, and fleshy disc. The plants of this order emit offensive odour from the glands which cover them. In the case of some of the genus *Dictamnus* the glands are filled with volatile oil, and in hot weather the surrounding atmosphere becomes so charged with it that a light coming in contact will inflame the air. The *Xanthroxylaceæ* are tropical plants of Asia, Africa, and America, and all possess in various degrees aromatic and pungent properties. "The *Simarubaceæ,* or Quassias, are known," says A. de Jussieu, "from all the rutaceous plants by the co-existence of these characters—namely: ovaries with one ovule,

indehiscent drupes, exalbuminous seeds, a membranous integument to the embryo, and by the radicle being retracted within thick cotyledons." The plants of the order are intensely bitter—so bitter that the *Ptiniæ*, which attack all other dried specimens, refuse to attack *Simaruba versicolor*.

The Orange (*Citrus aurantium*), which is at once the best known and most highly appreciated fruit, is a fine evergreen tree, originally from China, the islands of the Indian Ocean, and of those which are scattered over the Pacific. It is now largely cultivated in all the warm countries of the globe. Its glossy leaves are simple or compound, with one or many pairs of leaflets; the terminal ones, on winged leafy footstalks, are oval or lanceolate, and entire. When examined through a strong light these leaves present little bright spots, which are so many vessels full of an odorous volatile oil. Its flowers, whose elegance and delicate perfume are so well known, are composed of a somewhat bell-shaped calyx, adhering slightly to the disc; corolla with three to five petals, broad at the base, sometimes slightly combined, inserted on the outside of a hypogynous disk; the stamens, equal in number, double or any multiple of the number, distinct or united at the base—are disposed at the summit of a peduncle in paucifloral bouquets. The fruit we need not describe; it is separated by membranous divisions into many cells (Fig. 411), containing seeds at their inner angle; it is filled with soft and juicy pulp, sweet and slightly acid.

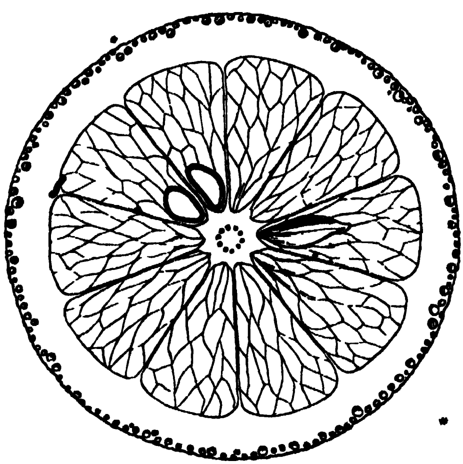


Fig 411 —Section of an Orange.

There are numerous varieties of the Orange; the best are the Chinese, the Maltese, the Lisbon and St. Michael's, and, later in the season, an excellent variety comes from Valentia. The

St. Michael's should be small, and flattened at the ends, with a thin smooth rind, the glands small, and the flesh a light ash-coloured pulp; but many coarse varieties come to market. Those from Valentia resemble St. Michael's. Lisbon and Malta oranges are larger, thicker in the rind, with glands; but the Chinese orange, when obtained of the best variety, excels all others for delicate flavour, sugary juice, and delicate aroma. The skin of this variety is always smooth and shining, and so thin that it is separated with difficulty from the flesh. The St. Michael's is probably a variety of this orange. The Bitter or Seville Orange is the fruit of *Citrus vulgaris*, but there are many varieties. This is the fruit from which the delicate condiment, orange marmalade, is prepared, and from which orange-flower water is produced.

The Orange is extensively cultivated in order to extract from its flowers and leaves the essential oil which they contain. In the South of France, but especially in Provence and Nice, the Orange is largely and successfully cultivated. In the South of Italy, about Sorrenta, whole forests of Oranges exist, the fruit of which is carefully harvested.

> "On the sonorous shore, where the sea of Sorrenta
> At the foot of the Orange unrolls its blue wave,"

sings Lamartine, France's great modern poet.

The Orange sometimes attains great age and dimensions. In the orangery of Versailles a magnificent Bitter Orange (*C. bigaradia*), known as "the Great Constable," is known to be upwards of four hundred and forty years old; its trunk is twenty feet in circumference, and its head rises forty feet high. It was planted in 1421 by the gardener of the Queen of Navarre, and came by cession to Chantilly. In 1532 Francis I., having confiscated all the property of the Constable de Bourbon, Lord of Chantilly, who had been driven into open rebellion to his king and country by tyranny, had the precious tree, which was quite unique in France, transported to his orangery of Versailles, where it remains in a highly flourishing state. The Bigaradier of the Dominicans, at Rome, dates from the year 1200. It is about thirty-three feet in height. The largest of these shrubs recorded was a former

inhabitant of the garden of the Dominicans, and is said to have been fifty feet high.

The principle to which odoriferous plants owe the qualities which render them so useful at the toilet has received the name of essential or volatile oil. The oils, volatile or essential, are met with most habitually in the flowers and the leaves; very rarely in the fruit. It happens sometimes that distinct oils exist in the same plant. Let us take the Orange for example. The essence drawn from the flowers of the Orange is very different from that furnished by the leaves. The essence furnished by the leaf differs again from that produced by the fruit.

The volatile oil is contained in the vesicles or cells which pervade all its parts; and so completely are these enclosed, that the plants may be dried without divesting them of the odorous principle, which still remains in the cavities. In other cases, particularly in the flowers, the essence forms itself on the surface of the organ, and is volatilised at the rate at which it is produced in the interior of the organs of the plant.

The mode of extracting these essences varies according to their nature and condition. Some of them may be extracted by simple expression. This may be done with the essential oils of the Citron and the Orange, which reside in the rind or envelope of the fruit. They are reduced to a pulp, adding water afterwards to the liquor produced by pressure, when the oil will swim on the surface of the water added.

But the greater part of these essences are produced by distillation. This process is performed by placing the leaves, flowers, or fruits of plants, with a sufficient quantity of water, in an alembic or still. The essential oils only enter into ebullition at a higher temperature than water, since their point of ebullition rises in general to 130° or 140° C. Nevertheless the steam, which is renewed unceasingly, escapes so rapidly into space that it is condensed in the bosom of the alembic. Let us explain. The vapour of the essential oils diffuses itself in the steam which fills the alembic, which, however, is condensed; a new supply of steam succeeds, which in its turn is saturated with the vapour of the oil. In this manner we can explain the rapid and continued evaporation of oils which only enter into ebullition at 140° in steam

which has itself only a temperature of 100° C. In order to increase the temperature of the water, marine salt, which boils at 109°, is added. This has the effect of increasing the evaporation of the oil. But the practice has its disadvantages, and in order to prevent the plants from being burnt by coming into contact with the bottom of the furnace, it is usual to place on the lower bars of the furnace a diaphragm pierced with holes, which supports the bed of leaves or flowers being distilled.

The steam which is thus condensed in the worm of the alembic is a mixture of water and essential oil, in which however the oil performs only a small part. In order to separate the two liquids and secure the oil, a very ingeniously conceived vase, known as the *Florentine receiver*, is employed. This vase separates the oil from the water on the simple principle of their respective specific gravities. Oil is lighter than water, consequently it floats on the surface; and if the mixed liquid is received in a vase or jar having a tube rising from the bottom, but whose highest part is placed at a lower level than that of the neck of the vase, as long as the united liquid flows from the still, the water will sink to the bottom and flow off, while the oil will accumulate on its surface.

The essential oils obtained by distillation from the Orange dissolve readily in fatty oils or alcohol, but very imperfectly in water. The condensed water, however, which passes with the oil, is a true watery solution of the essences: in short, orange-flower water. It is very subject to putrefaction, which is indicated by the appearance of flocculent flaky matter accumulating at the bottom of the vessel in which it is kept, which is commonly called *Orange Flower*. These organic particles are the seeds of decomposition, which light and air are sure to develop.

The AMYRIDACEÆ are trees and shrubs abounding in balsamic resins, and having all the appearance of the Orange, even to its dotted leaves, but the fruit forms a shell whose husk eventually splits into valve-like segments. The few known species are natives of tropical India, Africa, and America. The frankincense of Arabia is said to be the produce of *Boswellia serrata*. The *Balsamodendron myrrha*, a dwarf shrub of Arabia, yields the myrrh of Mecca, and most plants of the order yield resins and balsams of great commercial and officinal value.

GERANIALS.

This group, of which the Crane's-bills or Geraniaceæ are the type, are hypogynous exogens, whose most positive character is having a definite number of stamens, an imbricate or overlapping calyx, and a twisted corolla and symmetrical flowers. They are emollient and purgative in *Linum;* acid, nutricious, and aromatic in *Oxalids;* and aromatic and astringent in *Geranids.*

The Flaxes are annual or perennial, sometimes shrubby exogens, with alternate, nearly opposite, or whorled leaves, entire, without leaflets; hermaphrodite symmetrical flowers, generally five distinct styles; corolla with four or five petals; stamens equal and alternate with them; ovary often five-celled; fruit a one-seeded capsule.	CLXXXIII. Linaceæ.
Small trees or shrubs, with showy unsymmetrical flowers, alternate leaves, feather-veined, entire; sometimes plaited, permanent, cup-like, involucre; monodelphous stamens, and abundant albumen.	CLXXXIV. Chlænaceæ.
Herbaceous plants, under-shrubs, or trees; leaves simple or compound; distinct styles; carpels longer than the torus; seeds with abundant albumen.	CLXXXV. Oxalidaceæ.
Herbaceous plants, generally annuals, with simple opposite or alternate leaves, without stipules; flowers irregular and unsymmetrical, without involucre; distinct stamens, and no albumen.	CLXXXVI. Balsaminaceæ.
Herbaceous plants or shrubs, with turned stems, separable at the joints; flowers unsymmetrical; styles and carpels combined round a long-beaked torus.	CLXXXVII. Geraniaceæ.

The LINACEÆ, or Flaxes, are a small order of useful annual woody plants, valuable alike for their fibre, whose tenacity renders it invaluable, and its seeds which yield by expression the linseed oil of commerce. Their leaves are alternate, free from all trace of volatile secretions, and destitute of stipules; the body of the stem incapable of disarticulation. The order consists of two genera, *Linum* and *Radiola;* the first comprehending many species. The plants of the order are distributed throughout the temperate regions of the earth, particularly along the shores of the Mediterranean, in Europe and Africa; but it is supposed to be a native of the great plateau of upper Asia, whence it was introduced into Europe. It is the *Linum usitatissimum* which furnishes man with his first and last clothing. Martianus says that lint was first sown by the Egyptians, and that the priests of Isis made its uses known to them. From the time of Moses it was cultivated on a great scale in the plains of Egypt; under the Roman emperors the Egyptians were renowned for their linen fabrics. It soon spread over France, Germany, and other European countries, but in our times it has been most fully developed in Holland,

Belgium, and the North of France. In Britain it seems to have become the speciality of the North of Ireland.

Linum usitatissimum, which is the only species cultivated, is much more delicate in appearance than the *Cannabis*, or Hemp-plant. It branches out towards the summit, and carries its alternate leaves at an acute angle. Its flowers are of fine blue; the fruit a capsule containing ten small seeds. When the plant becomes yellowish, when its capsules begin to open and its leaves to fall, which usually happens at the end of June, the plant is at its maturity. It is gathered by tearing it up by the roots, and laid on the earth; after twenty-four hours it is bound up into small bundles, which are placed on end to dry. When ripe and perfectly dry, they are carried to the farmyard and the seeds thrashed out.

In preparing the fibre for lint, it is placed under water for a sufficient time to destroy the non-textile part of the stem by a species of fermentation which promotes decomposition.

The CHLÆNACEÆ are all natives of Madagascar, of whose uses little is known, but they present some curious anomalies to the botanist, along with remarkably showy flowers usually red in colour, borne in racemes or panicles enclosed in a five-toothed involucre.

The OXALIDACEÆ, or Wood Sorrels, formerly arranged among the Crane's-bills, have regular flowers, beakless fruit, albuminous seeds, and a general tendency to form compound leaves. They are plentiful in tropical and temperate America, and the Cape of Good Hope, but thinly diffused in colder regions. Almost all the species are distinguished by acidity, owing to the presence of oxalate of potassium. Some are bitter and stimulating. The tubers of some contain a considerable quantity of starch. It is best known to us as the common Wood Sorrel (*Oxalis acetosella*), common in the moist and shady woods in this and other European countries; it is one of the most elegant of our wild flowers, and the grateful acid of its leaves is well known. It was called of old, Allelujah, and Cuckoo's Meat, because, says old Gerarde, "when it springeth forth, the Cuckoo singeth most; at which time also Allelujahs were wont to be sung in our churches."

The BALSAMINACEÆ are best known by the *Balsamina hortensis*

of floriculture; natives of China and other tropical countries of the East, so remarkable for their unsymmetrical flowers. The nature of the parts which constitute this irregularity has been much discussed by botanists. "According to Roper and others," says Dr. Lindley, "two membranous external scales and a spur alone belong to the calyx, of which the two other sepals are usually deficient on that side of the flower which is opposite the spur: on the other hand, the corolla consists of a large upper or back-piece, and of two lateral inner wings, each of which consist of two petals. Kirsch considers the large back-piece of the flower to be composed of two sepals, and together with the spur and exterior scales to form a five-leaved calyx, while he finds in the innermost parts, a corolla of four petals united in pairs, and he assumes the fifth petal to be abortive.

The GERANIACEÆ, Crane's-bills, Geraniums, and Pelargoniums, form perhaps the most popular group of plants of the whole vegetable world. They are herbaceous, soft, or tumid stemmed plants; the young stems jointed, and separable at the joints like the vines; leaves opposite in the upper part, often alternate; the flowers hermaphrodite; regular or irregular calyx, with five equal segments; corolla with five petals, sometimes equal; stamens, ten in the Geranium. In the Pelargoniums they are rendered unequal by one of the petals being elongated into a hollow spur at the base, and closely united to the peduncle; corolla unequal; and the petals sometimes reduced to four or even two by abortion, clawed and alternating with the segments of the calyx; stamens seven, and more or less united by their filaments.

These distinctions between the Geranium and Pelargonium are perhaps too refined for popular appreciation, and in common parlance both genera are known by the common name. The long beak-like torus round which the carpils are arranged, and the membranous stipules at the joints, which are tumid or enlarged, are the true marks of the order. The Pelargoniums are chiefly natives of the Cape of Good Hope. The Geraniums and Erodiums, of Europe, North America, and Northern Asia.

In order to give the reader some idea of this interesting family, of which we meet with examples at every instant, whether we happen to be in town or country, in field or garden, let us

examine in succession the genus, *Geranium*, *Erodium*, and *Pelargonium*, of which the order consists.

The Geraniums, or Crane's-bills, have a calyx with five sepals, a hypogynous corolla with five free petals, and an andræcæum composed of ten stamens, five of which are large and five small. The latter are exterior and opposite to the petals; the larger stamens have a nectarous gland at their base; the filaments of these stamens are slightly attached at their base, and have two-celled anthers, opening from within by two longitudinal

Fig. 412.—Herb Robert (*Geranium Robertianum*).

clefts. The pistil is composed of an ovary with five cells, surmounted by five styles, more or less connected in their middle part, but free towards their summit, and bearing long stigmates the whole length of their internal surface. Each cell of the ovary contains two ascending anatropal ovules. The fruit is a capsule with five cells, each containing only one seed by abortion, and opening, as it were by a spring, with a sort of central axis, from

the base to the summit. Under its integuments the seed encloses an embryo without albumen, the flexous cotyledons of which are fitted into one another. Herb Robert (*Geranium Robertianum*) (Fig. 412) is frequently met with in hedgerows, shaded places, and on old walls. It flourishes in the months of April to August, and exhales a strong odour. This plant, which is sometimes used in medicine, is an annual, with a diffused branching, ascending, or straight stem, often of a reddish colour. It is coated with long, shaggy, patulous hairs, glandulous towards the summit. The leaves are divided into three to five petiolated segments. The peduncles are longer than the leaves. The petals are purple in colour, veined with white.

The *Erodium*, or Stork's-bill, one species of which, the Hemlock Stork's-bill (*E. cicatarium*) (Fig. 413), with pinnate leaves, is very common in all sandy places; has a corolla and calyx like the Geranium. But of the ten stamens five only are fruitful. Those which are sterile, that is to say destitute of anthers, are small, with flattened filaments, and are opposed to the petals in the exterior whorl. The fruit differs also in some particulars from that of the Geranium.


Fig. 413.—Storks-bill Geranium.

The Pelargoniums are particularly remarkable from the irregularity of their flowers. In the calyx the posterior sepal is prolongated at its base by a spur, which is a straight, hollow, nectarous horn or gland adhering to the peduncle. The corolla generally bears unequal petals. The upper two are often largest, the other three differ from each other. As to the andræcæum, whilst in the Erodium the exterior verticle is completely abortive,

in the Pelargonium, on the contrary, only three of the stamens of this verticle are sterile. The Pelargoniums are indigenous to the Cape of Good Hope. They enclose a volatile oil which gives them a strong odour, sometimes anything but agreeable, which is only redeemed by their beauty of form and colour. A great number of species are cultivated, to which horticulture has added innumerable varieties. Amongst others, we may mention *Pelargonium zonale*, the leaves of which are marked with a brownish band, and the petals of which are red or reddish-rose coloured, or whitish; *Pelargonium inquinans*, the shiny cottonous leaves of which stain the fingers with a brown rust, and the petals of which are scarlet or flesh-coloured; and *Pelargonium odoratissimum*.

SILENALS.

"At this point," says Dr. Lindley, "a considerable advance in structure is evident among exogens. Among these plants a corolla appears, with all its fragrance and gaudy colours, and the ovary is constituted, not by the rolling up of a solitary carpillary leaf, but by the complete consolidation of several." Accordingly we find among the SILENEÆ many popular plants of great interest. The qualities of *Dianthus caryophyllus* (Clove Gilliflower), so called from its spice-like odour, are sung by Chaucer :—

> "Ther springen herbes, grete and small,
> The licoris and the stetewall,
> And many a clove giliflore,
> ——— to put in ale,
> Whether it be moist or stale."

whence another of its popular names, "Sops in Wine."

They differ from the Geranials in their free placenta.

Herbaceous plants, stems swelling at the articulations, leaves opposite and entire, without stipules; flowers symmetrical; corolla conspicuous; amphitropal ovules; stamens double the petals in number; equal to the sepals and opposite to them.	CLXXXVIII. Caryophylaceæ.
Herbaceous or half shrubby branching plants, with opposite or alternate entire leaves, and scarious stipules; minute flowers with scarious bracts, with symmetrical calyx and corolla, the latter rudimentary; amphitropal ovules.	CLXXXIX. Illecebraceæ.
Shrubs or herbs, with entire alternate succulent leaves, without stipules, often with bundles of hairs in their axils; flowers axillary; unsymmetrical calyx and corolla; amphitropal ovules.	CXC. Portulaceæ.
Herbaceous plants or shrubs, with alternate leaves, stipules adhering round the stem; flowers in racemes, occasionally unisexual; calyx free, coloured; imbricate, in æstivation, orthotropal ovule; fruit a triangular nut.	CXCI. Polygonaceæ.

The CARYOPHYLLACEÆ as a group possess, with the exception of the Pinks and Carnations, little general interest. The beauty of form, rich colouring, and aromatic fragrance of the flowers, render these individuals of the family very general favourites. The order has been divided into—

Alsineæ, which are chiefly weeds, the best known being the common Chickweed (*Stellaria media*), of which birds are so fond, and

Sileneæ, which contains the Pinks, Carnations, and many popular plants.

Fig. 414.—Carnation (*Dianthus caryophyllus*).

The Pinks are herbaceous plants, rarely shrubs, with stem branching into forks, with tumid joints; leaves simple, opposite, entire; flowers generally hermaphrodite (Fig. 414); calyx five, sometimes four segments, either distinct, so as to form a tube, toothed at the summit, supplied at its base with two or several bracts. The corolla is composed of five free hypogynous petals, with lengthened linear aiglets, with crenulated dentate leaves. The stamens are double the number of the petals, their anthers bilocular, dorsally attached, and opening from within by two longitudinal clefts. The pistil is composed of an unilocular ovary, enclosing a great number of curved ovules, and surmounted by two very slight styles. The fruit is capsular, opening at the summit by the same number of valves as there are styles. A straight embryo is attached to the seed at the surface of a farinaceous perisperm. Seed sometimes flat and membraneous, sometimes round.

Pinks are herbs or under-shrubs, with knotty articulated stems, having opposed leaves and terminal, sometimes solitary, flowers, disposed in cymes. Many hundred varieties, of great beauty, are cultivated as florists' flowers. To grow them in perfection is quite a speciality in cultivation.

The Carnation (*Dianthus caryophyllus*) has red, rose-coloured, or white flowers, sometimes variegated or double. The Carnation of the poet (*Dianthus barbatus*), has the flowers in compact tufts, protected by slight and pointed bracts, which are of the same length as the tube of the calyx. The Feathered Pink (*Dianthus moschatus*) has very straight barbate petals, which are odorous, and of a pale rose colour, much varied, like the Pink, by cultivation. The Superb Carnation is truly worthy of this name. Rousseau says in one of his letters, speaking of this beautiful flower, "Have you seen the *Dianthus superbus?* At all events I will forward you one. It is really a most beautiful flower, with a sweet though somewhat faint odour. I can collect the seed very easily, for it grows in great abundance in a meadow which is just under my windows. It ought to be well exposed to the power of the sun, which nourishes it as it does grass."

Amongst the principal species belonging to the family of the Caryophyllaceæ we will mention the following:—the Soap-wort (*Saponaria officinalis*), an indigenous plant, the roots of which contain a soft, gummy, resinous matter, which makes a lather like soap in water, and to which sudorific medicinal properties are attributed. The Clove-tree (*Caryophyllus aromaticus*) has oblong ovate leaves, accuminate at each end, with distinct margins continued from the petiole; flowers in many-flowered cymes; stamens distinct, in four clusters; berry oblong, one or two-celled, with as many seeds. This is a fragrant, sweetish, agreeable stomachic, useful in cases of dyspepsia.

Many of the Lychnis genus are extremely beautiful:—*Lychnis dioica,* which the traveller frequently meets at the way-side; *Lychnis flos-cuculi,* the red petals of which are deeply cut, and which ornaments our fields in the spring time; *Lychnis coronaria,* or Rose Campion, a plant with purple flowers and whitish downy stem; the Corn Cockle (*Agrostemma gethago*), which abounds in our harvest-fields; *Gypsophyla elegans,* the whitish

flowers of which are seen in our gardens, balanced upon an extremely delicate pedicle; the Catch-fly, Pearl Grass, Chickweed, Stitchwort, and Ceraistes, are all prominent members of this order.

Chenopods.

A group of plants, the greater part of which have inconspicuous, monochlamydeous flowers, free central placentæ, an external embryo, curved or appended to the surface of a mealy or horny albumen.

Annuals or perennials, often with fleshy roots, or shrubs or trees, usually articulated at the tumid nodes; tubular, often coloured, calyx, which separates from its base, becoming a hard spermous pericarp.	CXCII. Nyctaginaceæ.
Herbaceous plants or tender shrubs, with alternate, entire, non-stipulate leaves; racemose flowers, with separate flat petals; stamens hypogynous, or nearly so, alternate with the sepals; one or several carpels.	CXCIII. Phytolaccæ.
Herbs or shrubs, opposite or alternate non-stipulate leaves; flowers in spikes, scarious, buried in imbricated bracts, pubescent; stamens hypogynous, five with separate sepals opposite the stamens; one-celled anther; and a single ovary, often containing several seeds.	CXCIV. Amarantaceæ.
Herbaceous plants or tender herbs, with alternate non-stipulate leaves; small flowers; calyx deeply divided with imbricated æstivation; stamens inserted in the base of the calyx; sepals flat, separate, and opposite the stamens; anthers two-celled; herbaceous naked flowers.	CXCV. Chenopodiaceæ.

The group is of little general interest. The Nyctagins are natives of the warmer parts of either hemisphere. The Phytolads are natives of inter-tropical America, Africa, and India.

Amaranths are most frequently natives of the tropics; a few are natives of Europe, and a considerable number of Australia.

The Chenopods include many of our pot-herbs, as Spanish Orach, and the well-known agricultural Beet and Mangold-wurzel plants, being very productive in sugar.

Piperals.

The Pipers are distinguished by their naked achlamydeous flowers, minute embryo, either external, or just within the surface of a large quantity of mealy albumen. The Piperaceæ are exclusively confined to tropical regions, common in America and the Indian Archipelago, and several species exist at the Cape of Good Hope. Chloranthaceæ differ from the Pipers in their naked embryo and pendulous ovule. They are also natives of the

hottest parts of India, America, and the West Indies. The SAURURACEÆ agree in habit with the Peppers, but differ in the compound nature of the ovary. They are natives of North America, China, and the North of India, growing in marshy places.

Shrubs or herbaceous plants, with articulate stems, opposite leaves; flowers sessile or pendulate, in spikes or terminal; stamens two or more, arranged on one side or round the ovary; a solitary carpel; erect ovules.	CXCVI. Piperaceæ.
Herbaceous plants or under-shrubs, with jointed stems; opposite and simple leaves, with sheathing petiole and intermediate stipules; flowers in terminal spikes; stamens lateral; a solitary carpel; suspended ovule.	CXCVII. Chloranthaceæ.
Herbaceous marshy plants, with alternate stipulate leaves; flowers in spikes, naked; stamens three and six, clabate and hypogynous; several distinct carpels; erect ovule and embryo lying in a vitellus.	CXCVIII. Saururaceæ.

Perigynous Exogens.

This sub-class, the third into which Dr. Lindley divides the great division of Exogenous plants, have uni-sexual, bi-sexual, or hermaphrodite flowers; stamens growing to the side of the calyx or corolla, a superior ovary, or nearly so; the first sub-class of hermaphrodite Exogens having been characterised by the stamens standing clear of the floral envelopes, or being, in the language of Jussieu, "hypogynous." But when there is adhesion between the stamens and either the calyx or corolla, it may be assumed that the one organ is in some way necessary to the other. For this reason, the "perigynous character where a real and manifest union of the parts, and not a slight inappreciable connection exists, is admitted to be a valid mark of the sub-class, whether the stamens grow on the petals or on the calyx, provided they grow on one of them."

This is essentially the old arrangement of Jussieu, but with this difference, that what the French botanist made a secondary distinction, in the system of Dr. Lindley and his followers becomes the primary characteristic; while his great distinctions of polypetalous, monopetalous, and apetalous, become secondary considerations.

Ficoids

Are for the most part herbaceous plants or bushes, with succulent leaves, monodichlamydeous flowers, central or axile placentæ, polypetalous corolla, if any, and an external embryo, curving round a mealy albumen. Carpels partially adherent with the calyx, in which respect they are hypogynous, but with strongly marked perigynous stamens. The Ficoids are plants only interesting to the botanist. They comprehend plants with fully-developed corolla, and others with a trace of it. Their characteristic marks are the perigynous stamens, curved external embryo, and mealy albumen, with axile placenta. The Basels are tropical, some of them pot-herbs in India and China. The seed-vessels exhibit the remarkable phenomenon of closing when placed in water and opening again when dry, which is no doubt a part of their economy.

Succulent, climbing, herbaceous or shrubby plants, with coloured calyx; naked flowers; distinct sepals, with stamens opposite them; no petals; fruit enclosed in a membranous or succulent calyx; single carpel; an erect seed.	CXCIX. Basellaceæ.
Herbaceous and shrubby succulent plants, with opposite simple leaves; flowers often terminal and showy; numerous narrow petals; definite sepals; indefinite stamens; inferior many-celled ovary; consolidated carpels, fruit split into regular stellate valves.	CC. Mesembry
Herbaceous plants or small shrubs, leaves succulent, alternate, or non-stipulate, often covered with watery pustules; flowers small and axillary; calyx three, five cleft, partially adherent to the ovary; petals none; stamens definite, alternate with sepals; ovary two to nine-celled; carpels, several consolidated.	CCI. Tetragoniaceæ
Small herbs, with opposite non-stipulate leaves; minute axillary sessile flowers; tubular calyx; four or five-toothed stamens, one to ten inserted in the orifice of the tube; no petals; ovary simple, superior, one-seeded; fruit a membranous utricle enclosed in the hardened calyx.	CCII. Scleranthaceæ.

The Basels are climbing, herbaceous, or shrubby tropical plants, with double coloured perianth, simple ovary, stamens inserted in the sides of the receptacle; characters which procured their separation from the Chenopods. The leaves of several are used as pot-herbs.

The Mesembryaceæ or Ice plants, are low branching, half shrubby, herbaceous plants, chiefly of the hot and arid plains of Africa, the shores of the Mediterranean, Australia, and South America. The *Mesembryanthemum macrorhizum*, the Ice plant, has the leaves and stem densely covered with papulæ, resembling globules of water or granules of ice, which sparkle in the sun; these secretions are saline, somewhat nauseous to the taste, and supply alkali for glass-works in the South of Europe, where they abound. Medicinally they are diuretic and demulcent. *M. edule*, the Hottentot Fig, is abundant on the sandy plains round the Cape of Good Hope, and is edible when ripe; the leaves, pickled, being substituted for the pickled cucumber, and its juice used medicinally. The Rose of Jericho (*M. tripolium*) has the singular property of gradually opening its seed-vessels on the approach of rain, contracting again when they become dry—a wonderful provision for the propagation of its species, for the seeds which have been closely shut up in the dry season are thus poured out of the open capsules when the growing season is at hand.

The Tetragoniaceæ are plants of no beauty and little interest. Like the Ice plants, they are found on the shores of the Mediterranean, at the Cape of Good Hope, and also in the South Sea

Islands; and the *Tetragonia expansa*, a New Zealand annual, is cultivated as a garden vegetable and substituted for spinach.

The SCLERANTHACEÆ are inconspicuous herbs of no known use.

DAPHNADS.

Evergreen Shrubs and trees sometimes of large dimensions, with monochlamydeous flowers; when a corolla exists the petals have the colour, texture, and quality of the calyx. Carpel solitary, and embryo almond-like, without albumen. Including the refreshing *Thymus*, whose name speaks of reviving strength; *Protea*, of variety and transformations; *Laurus*, of all that is green and aromatic. The *Cassytheæ* are tropical parasites of curious habit.

Shrubby, occasionally herbaceous plants, with simple alternate leaves; flowers unisexual by abortion, terminal or axillary, in heads, spikes, or clusters; perianth simple, coloured, petaloid, and tubular; four or five lobed; stamens equal to lobes of the perianth; ovary free, one or two-celled; fruit, a nut, fleshy and drupe-like; embryo straight.	CCIII. Thymelaceæ.
Shrubs or small trees, with umbellate branches; leaves hard, dry, opposite, or alternate, non-stipulate, whorled, or imbricate, often covered with stomata on both sides; flowers apetalous, generally hermaphrodite, rarely unisexual, in spikes or cone-like heads, proceeding from the axils of the leaves; stamens four; anthers sessile, bursting longitudinally; ovules erect, and calyx valvate.	CCIV. Proteaceæ.
Shrubs and trees, often of great size, with non-stipulate leaves, alternate, entire, rarely opposite or lobed; flowers regular, hermaphrodite or unisexual by abortion; stamens from eight or twelve, inserted in two rows in the margin of the disc, which lines the base of the perianth; anthers terminal, the inner series turned outwards, and the exterior turned inwards, bursting by recurved valves; ovary free, one-celled.	CCV. Lauraceæ.
Parasitical plants resembling the Dodders, having scales here and there in place of leaves on their twining stems; six-parted calyx, the three outer laminæ being small and monospermous; stamens petal-like, twelve, in four rows; anthers two-celled, bursting by recurved valves; fruit buried in a succulent permanent calyx.	CCVI. Cassythaceæ.

An interesting group of plants, whether we consider them as objects of floral beauty and fragrance, as associated with poetical literature, or in a medicinal and industrial sense. The THYMELACEÆ, or Spurge Laurels, include (1) the Daphnideæ, having the throat of the perianth naked; (2) the Gnidieæ, in which the throat is bearded with scales or glands; (3) the Drymispermidæ; the perianth being naked, and the flowers hermaphrodite. The name of the order is derived from Thymetæa, a plant spoken of by the ancients. The plants of this order occur in great abundance in the cooler parts of India, South America, South Africa, and Australia; they occur also in Europe. Their most common property is

causticity, which resides in the bark, which is very tough, and applicable to the purposes of cordage; thus *Daphne Lagetta*, the Lace Bark tree of Jamaica, is remarkable for the beauty of the inner fibre of its bark, and for the facility with which it is separated into layers and meshes, which by lateral stretching become equal in delicacy to the finest lace. The bark of *Gnidia Daphnoides* is manufactured in Madagascar into ropes; and a soft paper is made from the inner bark of *Daphne Bholua*, in Nepal, and from *Daphne Cannabina*, in China. Others, as *Passarina tinctoria* and *Daphne Gnidium*, yield a yellow die, used to colour wool in the South of Europe. The Mezereon of the garden (*Daphne Mezerium*), a deciduous plant, with spikes of white or purple flowers appearing on the plant before the leaves unfold, which is found wild in the mountain forests of the middle and south of Europe, yields berries of a smooth, shining, and bright red, which are extremely acrid and even poisonous. Linnæus speaks of a person having been poisoned by eating a dozen Mezerium berries. They are employed in Sweden to poison wild animals; and in Russia it is asserted that the Tartar women rub their cheeks with the berries to heighten their colour,—a permanent species of rouge. The Spurge Laurel of our hedgerows and woods is a handsome evergreen bush, with greenish flowers growing in clusters, concealed by the leaves, and have the appearance of the laurel.

The PROTEACEÆ are distinguished from Daphne by the hard woody texture of their leaves, their irregular tubular calyx, with valvate æstivation. Brown considers that the radicle pointing towards the base of the fruit is a distinguishing feature. The order is named from the diversity of appearance presented by the several genera composing it. They are generally handsome evergreen shrubs, much prized by gardeners for the beauty and singularity of their flowers. Many of the genera are named after distinguished botanists, and their geographical distribution is extremely interesting. They are almost entirely confined to the larger continents of the southern hemisphere, being found in New Zealand, New Caledonia, and wherever the shores of Australia have been explored, the Proteaceous plants have been found; the great proportion of the order existing there in the same latitude as the Cape of Good Hope. On the south-east coast it forms the chief feature in the vegetation; the Grevellias,

named by Dr. Brown in honour of the Hon. Francis Greville, are numerous in species there. The Hakeas and Banksiars—the latter named in honour of Sir Joseph Banks—are equally numerous. Inferentially the species belonging to the order, having been found in Madagascar and the lesser South Sea Islands, are supposed to be extensively diffused over Africa.

The LAURACEÆ are trees sometimes of great size, distinguished from imperfect apetalous Dicotyledons by the dehiscence of their anthers. Their habitat is cool places in the tropics of either hemisphere. *Laurus nobilis* is the only species found in a wild state in Europe. The species are all more or less aromatic and fragrant; some are valuable for their timber; others bear fruit like the nutmeg. Some yield fixed and essential oils, and an abundance of camphor. Cinnamon and cassia are well-known products of the order from the hottest parts of Asia, the former being produced from *Cinnamonium Zeylanicum*. Among the timber trees of the order is the Greenheart of Demerara (*Nectandra Rodiæa*).

The CASSYTHACEÆ, found in the hottest parts of the world only, are parasitic plants, resembling the Dodders, of no known use. Their structure is nearly that of Laurels, the difference being in the fruit, which in Cassytha is enclosed in a berried calyx. Little is known of their properties or uses.

ROSALS.

Trees, shrubs, and herbaceous plants, partaking somewhat of the Lauraceæ, so far as their apetalous and aromatic characters are concerned, but characterised by their apocarpus fruits, small number of seeds, and amygdaloid embryo, with little or no albumen. Their flowers are monodichlamydeous, with distinct carpels, sutural placentæ, definite seeds, corolla, if present at all, polypetalous.

Aromatic, with square stems, leaves opposite; simple scalrons; non stipulate flowers, axillary or terminal, hermaphrodite or unisexual by abortion; stamens numerous, inserted in the rim of a fleshy tube; ovaries several; superior distinct embryo, convolute, with inferior radicle.	CCVII. Calycanthaceæ.
Trees or shrubs, with simple stipulate leaves, alternate, no glands, veins parallel with each other from the midrib; polypetalous or apetalous flowers in racemes, panicles or corymbs; calyx five-lobed; stamens definite, or none; a solitary carpel; style proceeding from the base; fruit a drupe, one or two-celled.	CCVIII. Chrysobalanaceæ.

Herbaceous plants, shrubs, or trees, having alternate, mostly compound leaves; petiole swelling at the base; polypetalous or apetalous flowers; a papilionaceous corolla, leguminous fruit, and solitary carpel; style proceeding from the apex.	CCIX. Leguminaceæ.
Trees or shrubs, with simple alternate leaves, usually glandular towards the base; regular polypetalous flowers, white or pink, in umbels or single; petals five; stamens twenty, rising from the throat of the calyx; solitary carpel; and drupaceous fruit.	CCX. Drupaceæ.
Trees or shrubs, with alternate stipulate leaves, simple or compound; flowers, polypetalous, regular, solitary, or in terminal cymes, white or pink; calyx adherent, five-toothed; petals five, unguiculate, the end one anterior; stamens indefinite; carpel adhering to the calyx dorsally.	CCXI. Pomaceæ.
Herbaceous plants or under-shrubs, with simple alternate lobed leaves, compound stipules, apetalous flowers, small, often capitate; calyx a thickened tube; petals nine; stamens definite; fruit a nut, solitary, enclosed in hardened tube of the calyx.	CCXII. Sanguisorbaceæ.
Herbaceous plants or shrubs, leaves simple or compound, alternate, often with two stipules at the base; flowers polypetalous, hermaphrodite, or unisexual by abortion; calyx four or five-lobed; carpels free from the calyx, and nearly free from each other; fruit one-seeded nuts.	CCXIII. Rosaceæ.

The CALYCANTHACEÆ are hardy perigynous exogens, well known in the garden for their delicious fragrance and for their chocolate-coloured flowers, with segments overlying each other in several rows. They present an imbricated calyx and corolla which pass insensibly into each other, combining at the base into a thick flesh tube; a small number of perigynous stamens with adnate anthers, with projecting connective; their hood presents four imperfect axes with concentric circles to each, lying at equal distances from the bark, which gives a square form to the circumference. *Chimonanthus* is called the Japan Allspice; and the bark of *C. floridus* is sometimes used as a substitute for cinnamon.

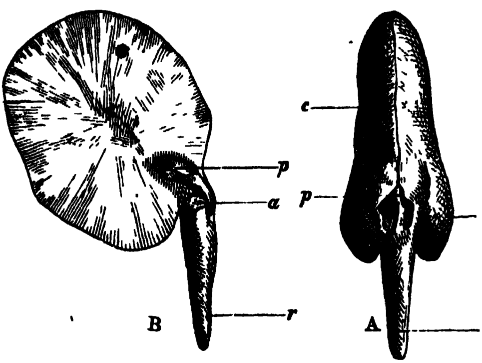


Fig. 415. The Bean.
A, embryo, and seed without the husk. B, embryo minus one cotyledon. *r*, radicle; *c*, cotyledon; *c r*, point of separation of cotyledon.

The CHRYSOBALANACEÆ are exclusively natives of the tropics of Africa and America, and probably of the Indian forests. They are stone-fruit, or plums, the drupes of many of which are eatable. (Fig. 415.)

The LEGUMINACEÆ, or as some botanists term them, the FABACEÆ, form an extensive natural order, consisting of her-

baceous plants, shrubs, and great trees, extremely variable in appearance. Their most common feature is to have what are called papilionaceous flowers, which are readily recognisable, and leguminous fruit; although these characters do not always exist throughout the order, in some cases a kind of drupe taking its place, while the Mimoseæ have regular flowers, and indefinite hypogynous stamens. The nominal fruit of the Leguminaceæ, however, may be considered a *Legume*, namely, a dry simple carpel, with a suture along both its margins, which opens at maturity by the line of suture into two valves.

This vast assemblage of plants useful to man, has been subdivided into groups which we shall abbreviate in order to give a comprehensive view of the whole.

Tribe I. Padalyrieæ.—Corolla papilionaceous; stamens ten; pod free, two-valved. Almost all natives of Australia, with the exception of *Baptista tinctoria*, the Wild Indigo, a bush of the United States of America, three feet high, which yields a pale blue colouring matter, resembling Indigo of an inferior kind.

Tribe II. Loteæ.—Corolla papilionaceous; stamens ten, in one or two bundles; pod two-valved, continuous, one-celled; rarely two-celled, from the suture being bent inwards. The Loteæ are rich in fibre; Madras Hemp, the brown Hemp of India, being the produce of *Crotolaria juncea*. Some of the Lupines so extensively cultivated by the Romans belong to this tribe; as do also the beautiful yellow-flowering Gorse, Furze, or Whin, the *Ulex Europeus*, of which Linnæus preserved a plant in his greenhouse at Upsal. The Spanish Broom (*Spartium junceum*) yields a delicate fibre from which a fine linen cloth is made. The common yellow-flowered Broom (*Cytisus scoparius*), and the graceful Laburnum (*C. Laburnum*), all belong to one section of the tribe; while the Lucern (*Medicago sativa*), the Trefoil (*M. lupulina*), the Mililotus, and the Clovers, (*Trifolium*), all so valuable in agriculture, form another section; and the Indigo plant (*Indigofera tinctoria*); the common Liquorice (*Glycyrhiza glabra*), the ornamental Bastard Acacia or Locust-tree (*Robinia pseud-acacia*), and the Astragalus, from which the Gum Tragacanth of commerce is obtained, form a third and fourth section of the same tribe.

TRIBE III. VICIEÆ.—Corolla papilionaceous; stamens ten, in two bundles, that is, nine joined together and one free; pod, two-valved and continuous.

In this section are ranged those leguminous plants which are cultivated for food, under the name of Pulse. Here we have the Bean (*Faba vulgaris*), from which the cultivated Beans have been derived (Fig. 240); the Peas (*Pisum sativum*); the Lentils (*Ervum lens*); the Tares or Velities (*Vicia sativa*); the Everlasting Pea (*Lathyrus latifolius*); the Sweet Pea, so fragrant and graceful.

TRIBE IV. HEDYSAREÆ.—Corolla papilionaceous; stamens ten, in one or two bundles, nine jointed and one free, or five in each bundle; pod divided transversely into one-seeded joints or cells.

The Ground nut of America, the fruit of *Arachis hypogæa*, and *Adesmia balsamifera*, better known as the Jarella plant of Chili, bears flowers of great beauty; and the Moving plant of Bengal (*Desmodium gyrans*), and the French Honeysuckle (*Hedysarum coronarium*), and Santfoin, the well-known Fodder plant, belong to this tribe.

TRIBE V. PHASEOLEÆ.—Corolla papilionaceous; stamens ten, united in two bundles, rarely in one; pod two-valved, continuous, many-seeded, with a cellular transverse membrane between each, divided by ridges, but never articulated.

In this section the most remarkable plants are *Clitoria ternatea*, said to be a cure for croop; *Soja hispida*, a plant of Japan, from which *soy* is prepared; the Ox-eye Bean (*Mucuna urens*); the Shady Coral tree (*Erythrina umbrosa*), grown in the Caracas and Trinidad for shading the young chocolate plantations; the Dhak tree of India (*Butea frondosa*), from which Bengal kino, or butea gum, is drawn.

This section also includes the Scarlet Runners (*Phaseolus multiflorus*), which is at once a beautiful ornament to our gardens and yields a useful vegetable for the table; the Dwarf Kidney Beans and Haricots, and other useful or ornamental plants, also belong to the section.

TRIBE VI. DALBERGIEÆ.—Corolla papilionaceous; stamens ten, united either in one or two bundles; pod not opening, often divided into cells by internal ridges.

The Dalbergias yield a reddish resin, which has been sold for dragon's blood. *Pterocarpus draco* is one of these; East Indian kino is the inspissated juice of *P. marsupium*, a native of Coromandel; the Cabbage tree (*Andira inermis*). The Tonquin Bean is the seed of *Dipterus odorata*, belonging to this section.

TRIBE VII. SOPHOREÆ.—Corolla papilionaceous; stamens ten, rarely eight or nine; free pod, continuous, unarticulate, unopening, or two-valved.

The Balsam of Peru, supposed to be extracted from *Myrospermum peruiferum*, and the Balsam of Tolu, from *M. toluiferum*, belong to this section. *Virgilia capensis* is a handsome tree. The Judas-tree (*Cercis siliquastrum*), and many other trees useful in medicine or yielding commercial products, belong to this section.

TRIBE VIII. CÆSALPINIEÆ.—Corolla irregular, sub-papilionaceous, or almost regular, sometimes absent; stamens ten, or fewer, free, sometimes serrated; pod dry and two-valved.

The section includes many medicinal plants, as the Necker-tree (*Guilandina bonduc*), useful in intermittent fevers, the seeds of which are used as beads and marbles. The Brazil-wood of commerce (*Cæsalpinia Braziliensis*) is a tree of San Domingo, twenty feet high. Many others of the genus yield valuable dyes. *Hæmatoxylon campechianum* yields the logwood-dye; *Tamarindus Indicus*, a large spreading tree of sixty feet, yields the well-known tamarind; the true Officinal Senna is the produce of *Cassia lanceolata;* and *C. obovata* is the Alexandria Senna; all the Cassias producing similar local varieties of the medicine. *Cassia fistula*, a tree forty or fifty feet high, produces pods upwards of a foot in length, whose mucilage is known as the Purging Cassia. The wood of *Aloexylon agallochum* is much esteemed for its fragrant odour: this is the Aloe-wood of the East. Gum Anime is produced by *Hymenæa courbaril*, a lofty tree of South America. The Copal of Mexico is produced by another species of *Hymenæa*. The bark of *Bauhina racemosa* is used to make ropes: it is a climbing tree, known in India as the Maloo Creeper, which hangs in elegant festoons from the top of the loftiest trees, "which one is surprised," says Dr. Royle, "from the distance of its roots from the stems, how it could reach." *Amherstia nobilis* is a Burmese tree thirty to forty feet

high, which, "when in flower," as Dr. Wallich tells us, "is profusely ornamented with pendulous racemes of large vermilion-coloured blossoms, forming objects of beauty unequalled in the Indian Flora." In short, a vast proportion of the trees belonging to this section of *Leguminaceæ* are distinguished for their beauty or utility, and in most instances they possess both qualities in the highest degree.

TRIBE IX. MEOINGEÆ.—Corolla irregular; stamens eight or ten inserted on the top of the disc which lines the base of the calyx, free at the base, connate at the middle; pod with three valves, one-celled, lined with a fungous substance in which the seeds are embedded.

Moringa pterygosperma is called the Horse-radish-tree, the roots when young being used as we use Horse-radish. The oil of Ben is procured from its seeds, and also from *M. aptera*. This oil, inodorous and clear itself, keeps for years without becoming rancid: it is used for extracting odours from other odoriferous flowers.

TRIBE X. SWARTZIEÆ.—Flowers perfect, somewhat irregular; petals and stamens hypogynous; stamens rarely inserted in the calyx, either nine or ten, free; pod two-valved or drupaceous, unopening.

In this section we find the Cane-wood of commerce, the produce of *Baphia nitida,* an African tree of fifty or sixty feet high. *Erythrophlæum guineense* is an immense tree of Guinea, growing a hundred feet high, called the Ordeal-tree, the juice being used by the natives as an ordeal of guilt or innocence. The red juice is swallowed in certain portions by the accused, and those who cannot withstand its effects are considered guilty.

TRIBE XI. MIMOSEÆ.—Flowers regular, generally unisexual, sometimes hermaphrodite; calyx four or five-lobed, equal, valvate; petals four or five, equal, inserted on the receptacle; stamens inserted with the petals.

In this section we find the Nitta-tree (*Parkis Africana*), a large tree of Western Africa, where the seeds are roasted and used as we do coffee. The pulp of the pods surrounding the seeds is sweet and farinaceous: it forms a pleasant drink, and is sometimes made into a sweetmeat. *Adenanthera pavonina* is a gigantic

tree one hundred feet high; its timber is valued for its solidity; its seeds, of a lively scarlet, are highly polished, and the leaves, powdered, are used in some of the religious ceremonies of India. Several kinds of *Prosopis* yield edible fruits. Gum-arabic is the produce of several species of Acacia, the most important being *A. vera* and *A. Arabica.* All the Acacias yield gums, and many of them are valuable for their timber, and for turning purposes. *A. melanoxylon,* called Black wood, is a hard, close-grained, dark, and richly-veined cabinet-wood of South Africa, much used by the colonists.

The pods of *Castanospermenum Australe* contain four seeds as large as a Spanish chestnut, which are eaten by the natives of Moreton Bay. *Brya ebenus,* a small tree, called American Ebony,

Fig 416 —Branch and Flower of Robinia pseud-acacia

is the ebony in common use. Its slender branches are flexible, and used as riding switches in the West Indies, where it was formerly used to punish refractory slaves.

The Acacia, or rather Robinia (*Robinia pseud-acacia*), which will serve us as a type of the *Papilionaceæ,* was originally from North America. It was first cultivated in France by Robin in the

year 1601. It is a tree of great size, terminated by an ample rotund head, with spreading branches; its russet bark is marked with deep longitudinal crevices; its branches are supplied with spines in the shape of strong prickles; its leaves are composed of numerous oblong leaflets; and its white and very odorous flowers are disposed in well-furnished hanging bunches (Fig. 416).

Let us see what is the structure of the flower of the Acacia.

The calyx, which is composed of five petals, is nearly campanulate, almost bilobate, with upper lip truncate, or emarginate and bidentate. The lower lip is bifid. The corolla is composed of five petals. According to the expression used by botanists, it is said to be "papilionaceous." That part of the corolla called the "standard"—that is, the fifth petal—is orbicular, spreading backward, scarcely extending beyond the wings, which are free; and the casina—viz. the two anterior petals or seed—are pointed. The stamens are ten in number, of which nine form one bundle, leaving only one free. Their anthers are bilocular, opening from within by two longitudinal clefts. The unilocular ovary encloses a score of ovules. The style is very slight, and the stigmata obtuse. The fruit, which forms an important character in this family, is a pod; the seeds are of a compressed ovoid shape, shiny, and of a dark colour, and enclose an embryo without albumen.

The AMYGDALEÆ—or, as Dr. Lindley terms them, the DRUPACEÆ—include the Almond, Peach, Nectarine, Apricot, Plum, and Cherry; fruits which are produced through the whole of Europe, Asia, and America. The Almonds are divided into Bitter and Sweet Almonds, the former being the produce of *Amygdalus communis amara*, and the latter of *A. com. dulcis*. The Sweet Almond is chiefly imported from Malaga; Bitter Almonds chiefly from Morocco.

The Peach (*A. persica*), Fig. 417, nearly allied to the Almond, belongs to the same genus; and there are said to be instances of successful impregnation of the Almond with the pollen of the Peach. In this country the Peach, Apricot, and Nectarine only prosper as wall-fruit, where the reflected warmth of the wall, careful pruning, and such shelter as can be given from frost in the spring, lead to large crops of delicious fruit: but the result is very precarious. Under the generic name of *Prunus*, Linnæus

included the Apricot, Plum, and Cherry. They are known by their numerous stamens rising from the origin of a tubular calyx, and by their drupe-like fruit. The leaves and other parts of the plant yield hydrocyanic acid, which renders all the species more or less deleterious, although the quantity of the poison is too minute to be injurious under ordinary circumstances.

Fig. 417. Blossom of the Peach.

The Almond (*Amygdalus communis*) may be taken as a type of the AMYGDALACEÆ, which belong to the large class of *Rosaceæ*. This tree, indigenous to Africa, is now cultivated throughout the whole of Europe. Its branches are elongated, of a clear, very glossy green, and slightly glaucous; the leaves are alternate, lanceolate, and dentate like a saw. The flowers appear before the leaves; they are large, solitary, and germinate on the whole length of the branch. A hollowed receptacle, in the shape of a cup, bears upon its edges five sepals, five petals, and from fifteen to thirty stamens, sheltering a sessile unilocular ovary, containing two collateral anatropal ovules suspended at the summit of its single cavity. It is surmounted by a terminal style. The fruit is a compressed oblong drupe, with fibrous coriaceous dry flesh, incompletely bivalved, opening irregularly. Its stone is rugose, creviced, and hard; it generally encloses only a single ovule, by reason of the abortion of the others.

There are two varieties of the Almond; the seeds of one are sweet, of the other bitter.

The Peach-tree (*Amygdalus persica*) only differs essentially from the Almond-tree in its fruit, the flesh of which is thick, fleshy, and succulent; and in the structure of its stone, which is furrowed with deep anfractuosities. This species, originally from Persia, presents three interesting varieties. In the two first the fruit is downy, in the third glossy. The first variety has firm

flesh adhering to its nucleus; it comprehends the White, Yellow, Red, and Monster Clingstone Peach. In the second variety the flesh is melting and easily detached from the stone. These are Peaches, properly speaking, the different varieties of which have given us fruits as remarkable for their flavour as their beauty. The third variety is distinguished from the two preceding by its pellicle, which is shiny, and not tomentose. It comprehends the Violet Peach, the flesh of which easily detaches itself from the stone, and the Nectarine, the flesh of which adheres to it.

Of the genera *Prunus*, the flowers present characteristics nearly identical with those of the genus *Amygdalus*, but it differs in the structure of the fruit. It comprehends the Apricot, Plum, and Cherry.

The Apricot (*Prunus Armeniaca*) gives a velvety drupe, the shiny stone of which has one obtuse side and the other supplied by a sort of keel, running along two lateral furrows. This tree is a native of Armenia. It is of middle size, and has rotund leaves, nearly in the shape of a heart, terminating in a point, and dentated. The flowers are white, and disposed in little clusters very close together at the upper part of the branches. We may mention, among the varieties cultivated in France, the Early Apricot, the fruit of which is of a yellowish colour, as large as a nut, with a heavy and rather bitter saffron-coloured flesh. The Angoumais Apricot is of middle size, and the flesh is red and pleasantly fragrant. The Common Apricot (Peach Apricot), the largest of all, the flesh of which is yellow, melting, and of a peculiar flavour, is the variety chiefly cultivated in England.

The fruit of the Plum-tree is smooth, and covered with a glaucous bloom. The stone presents one side rotund and hollowed into one furrow, on the other side there are two lateral furrows. All cultivated Plums with alimentary fruit have but two stocks on which the varieties are grafted, perhaps we might say but one, namely, *Prunus insititia* and *domestica*.

The Domestic Plum is a fine branching tree, of from ten to twenty feet in height, with spreading branches, elliptical, sharp, crenullate, and dentate leaves. Its flowers are of a white colour, and appear before the leaves. It is often met with in hedges and on the borders of woods, but never in the interior of forests.

This fact leads to the supposition that it is not indigenous. The *Prunus insititia* is a shrub of from six to ten feet in height, sometimes with prickly spines. It is found in the same places as the last mentioned.

The most esteemed varieties of the Plum appear to have come from the East, probably from Damascus. The number of the varieties is very considerable. Some have a round yellow fruit, as in the Mirabelle, or Golden Drop; in others the fruit is round, green, spotted with purple, like the Reine Claude; in others, again, it is oval and globular, bluish or violet coloured, like the Late Black Damson, Violet Damson, &c. In others it is nearly round, and the colour of wax, like the White Magnum Bonum. The flesh of this is sweet and scarcely sapid. A fine and delicate aroma places the others in the highest rank among fruits.

The Cherry-tree (*Prunus cerasus*) furnishes a fruit (a drupe) with a smooth surface, without glaucous efflorescence. It is a rather tall tree, with straight cylindrical trunk, covered with a smooth and shiny bark. Its leaves are sharp, dentate, and strongly ovate. The white and precocious flowers of the Cherry form panicles. This species comprehends innumerable varieties, which it would be foreign to the object of this work to describe.

The Black-heart Cherry is the fruit of the Late Cherry (*Prunus semperflorens*), the flowers and fruit of which appear together in the autumn. The Wild Cherry-tree (*Prunus avium*) gives fruit known under the name of Wild Cherries, which is used in the manufacture of Cherry-water (*Kirschwasser*) and of Ratafia.

Fig 418 —Blossom of Pyrus Communis

The Bigarreau Cherry-tree is a species nearly allied to the preceding, and furnishes large red or yellow heart-shaped fruit, the flesh of which is with difficulty separated from the stone. This is

reversed in the case of the fruit of the Guigne, a species very like it, and which supplies us with various fruits, known under the name of Red Guigne, Pentecost Cherry, &c.

In the POMACEÆ, which like *Drupaceæ* are usually treated as a sub-order of the natural family *Rosaceæ*, we have the Apples, Pears, Quinces, Medlars, and other fleshy fruits having the indefinite stamens inserted in a ring, in the throat of the calyx (Fig. 418); the flowers solitary, white or pink; the ovary adherent to the side of the calyx *c* (Fig. 419), the sides of the calyx tube *t c* fleshy; the endocarp *e* cartilaginous; the seeds *s* solitary. The Pomaceæ are found plentifully in Northern Asia, Europe, and North America; they are rare in Mexico, unknown in Africa, except on the Northern shore, and are entirely unknown in the Southern hemisphere. Malic acid is contained in considerable quantities in the Apple and the Mountain Ash (*Pyrus aucuparia*); prussic acid occurs in the seeds of most of the species, and abundantly in some, as the *Cotoneaster*.

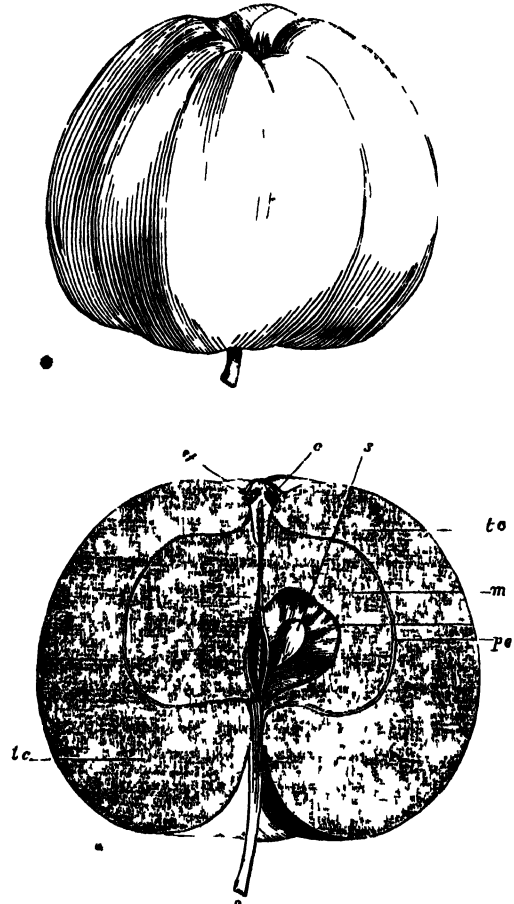


Fig 419.—Pome and Section of Pyrus malus.
c, calyx, *st*, stamens, *tc*, calyx tube, *pe*, epicarp, *m*, mesocarp; *e*, endocarp, *s*, seed.

The Apple blossom has a calyx with five lobes; a corolla with five nearly orbicular spreading petals; and a large number of stamens. The ovary is inferior, and generally presents five cells, with two collateral ascending and anatropal ovules; it has five free styles slightly coherent at their base.

In the Pear (*Pyrus communis*) the fruit is nearly conical, not imbricated at its base; the flesh is sweet, and towards the heart presents stony grains. In the Apple (*P. malus*) the fruit is generally globular, always imbricate at the base, and not growing any thinner towards the peduncle; the endocarp is coriaceous and cartilaginous, like that of the pear; the flesh is acid, and never stony. The Common Apple grows spontaneously in all European forests. Its rotund cyme is broader than it is high; its leaves are dentate, sharp-pointed ovals, more or less cottonous on their lower face; its large red or white flowers form a kind of cluster at the summit of the young branches. The Apple-tree is much modified by cultivation. From it we have the Pippins, Russets, Codlings, and many others. *Malus acerba*, a species nearly allied to the preceding, is commonly known under the name of the *Cyder Apple;* it is very common in forests; its culture takes the place of that of the vine in many parts of Brittany, Normandy, and Picardy.

The Common Pear grows naturally in many forests of Europe; it is a tree with knotty branches, which attains from ten to twenty feet in height; its leaves, borne upon long petioles, are dentated ovals, without hairs. The flowers are white, and disposed in corymbes. From the wild state, the fruit, like that of the Apple, is ameliorated and much varied by culture; from it we have the Butter-pears, Doyeunes, Bergamots, Saint Germain, Increvert, Bon Chretien, Messire Jean, and hundreds of other varieties.

In the same group as the Pyrus tribe, that is to say, in the tribe *Pomaceæ*, is the Medlar (*Mespilus germanica*), the inferior ovary of which (like that of all the other genera we have mentioned) has five biovulate cells, with straight anatropal and colateral ovules, and the fruit is crowned by five calycinal thongs, enclosing five bony shells. The genus *Cydonia*, or Quince, the five ovarious cells of which enclose several ascending ovules, and the fruit of which possesses a characteristic odour, and an acrid flavour; the genus *Cratægus*, or Hawthorn; the Medlar of Japan (*Eriobotrya Japo-*

nica), which furnishes a yellow, melting, sweet and acid comestible fleshy fruit; and the Strawberry (*Fragaria*),—all belong to this order.

The SANGUISORBEÆ, or Agrimonies, are slightly bitter aromatic herbs, common in hedgerows, sometimes employed in medicine for their astringent qualities, and also as a dye.

The ROSACEÆ were formerly gathered into a single family, but they are now divided into several groups; the Rose, Bramble, and Meadow Sweet also belong to this group or tribe, at which we will glance successively.

The ROSES, properly so called, have a calyx formed of five foliaceous thongs, which alternate with five petals; its perigynous stamens are numerous, and their filaments free, bearing anthers with two cells, which open from within by two longitudinal clefts; all these organs are inserted upon the upper edge of an oval or spherical receptacle, confined at the base. At the bottom of this receptacle, which resembles a bladder or small bottle, a large number of free pistils stand erect; the ovary is unilocular, with a single anatropal ovule and an elongated style, surmounted by an obtuse stigmata; when arrived at maturity these pistils become achenes, which envelop the receptacle and become fleshy; the seeds enclose a straight embryo, destitute of albumen. Roses are often supplied with prickles or spines, alternate leaves, having stipula adjoining the petiole, and beautiful terminal flowers, either solitary or in clusters, which have a sweet and unequalled odour. The Rose long ago gained the sceptre for beauty over all the most beautiful flowers of our gardens and hedgerows.

There are numerous species of the genus *Rosa*, from which innumerable varieties have been produced. We must content ourselves here with briefly describing a few well-known species. The Dog Rose (*Rosa canina*) is an indigenous species, common in our hedgerows and upon the borders of woods, the fruit of which is of a coral red, forming a yellowish acid and astringent pulp, enclosing a number of hard hairy pips or seeds. The Red Rose (*Rosa gallica*) is represented in Fig. 420, the leaves of which were formerly employed in medicine as astringents, and then designated under the name of *R. officinalis*. The Red Rose was brought from Syria to France

in the times of the Crusades. The Rose with a hundred leaves (*Rosa centifolia*), whose admirable flowers are the ornament of our gardens, came originally from the Caucasus. The Damask Rose (*Rosa Damascus*) is called also the Rose of Four Seasons, and still preserves some stamens not changed into petals, the odour of which

Fig. 420.—Branch of the Red Rose (*Rosa gallica*).

is very sweet, and which is used in the preparation of rose-water. From the Musk Rose (*Rosa moschata*), like the two preceding species, a volatile oil is extracted, called Essence of Rose, &c.

Tribe of Brambles.—Brambles (*Rubus*) (Fig. 421), like the Rose, have five sepals, five petals, and numerous stamens and pistils; but in this case the receptacle, instead of being hollowed out in the shape of a bottle, rises like a disc or cone, and upon

this the pistils are disposed. When at maturity these become changed into little drupes, grouped together upon a spongy and persistent receptacle. Bramble shrubs are sarmentose, and provided with prickles, with simple, alternate, digitated leaves, in threes, with stipules adhering to the petioles, and terminal or axillary flowers, which are rarely solitary, but are disposed in a panicle or corymb. We often meet with the Bramble, or properly speaking, the *Rubus fruticosus*, the Dewberry with its blue flower (*Rubus cæsius*), represented in Fig. 421, and the Raspberry plant (*Rubus idæus*).

Fig. 421. The Dewberry (*Rubus cæsius*).

In the Strawberry the calyx is composed of five sepals joined at the base, and furnished with a calicule with five divisions. The stamens, which are numerous, are inserted upon the edge of a receptacle in the shape of a cup, which rises again at the base like the bottom of a bottle. The numerous unilocular pistils are inserted upon the lower part of the receptacle, surmounted by a lateral style. They are changed at the time of maturity into achenæ, which, as we have already mentioned, are implanted upon the receptacle, and become fleshy and succulent. The Strawberry plants are long-lived, grassy perennials, with alternate trifoliated leaves, sometimes simple by abortion, with stipules adhering to the petioles. The *Fragaria vesca* furnishes several wild varieties known under the name of Wood Strawberries; *Strawberries of all Months, Bush Strawberries.* The *Fragaria chilensis* is known under the name of the Pine Strawberry, the fruit of which is erect, rose-coloured, white within, and sometimes as large as a pigeon's egg. The Mountain Strawberry (*Fragaria collina*) is not very common; its fruit is of a lively red; ovoid, contracted at the base, almost destitute of

carpels, and shiny in its lower parts; it is with difficulty detached from the bottom of the calyx.

The Meadow Sweet (*Spiræa ulmaria*), which, like the preceding genera, have a five parted calyx and corolla, and numerous stamens, generally also five pistils, rarely from three to twelve. They are sessile, at the bottom of a receptacle hollowed like a rather deep cup, and enclosing in a single cavity two series of anatropal ovules, generally suspended. When at maturity these become folicles which open at the summit by two valves. Meadow Sweets are herbs, shrubs, or under-shrubs, with simple or composed alternate leaves, with stipules adhering to the petioles, having axillary or terminal flowers, disposed in white or red bunches, in corymbs, panicles, or fasicles.

The Dropwort (*Spiræa filipendula*) is frequently to be met with in chalky places; its flowers white, in terminal corymbs. *Spiræa ulmaria* (Queen of the Meadows) displays its corymbs of delicate white flowers at the edges of water, or in damp fields. Another species, the *Spiræa aruncus*, is not common among British plants; the root was highly extolled in olden times as a tonic and febrifuge. These three species are perennial herbs. Amongst the ligneous species which belong to ornamental gardening, many have showy flowers, generally white or red. The name is derived from *speirao*, to become spiral, in allusion to the ease with which their flexible branches twist into garlands.

SAXIFRAGALS.

Perigynous exogens, consisting of herbs, shrubs, and trees, with monodichlamydeous flowers—that is, having a calyx only, or both calyx and corolla with consolidated carpels; corolla polypetalous, if any.

Herbs, shrubs, and sometimes trees; leaves alternate, sometimes in whorls, with or without stipules; flower stems simple, often naked, with styles equal in number to the carpels.	CCXIV. Saxifragaceæ.
Shrubs, with opposite simple leaves, without stipules, smooth or downy; flowers in cymes; styles distinct; calyx adherent to the ovary; fruit a capsule.	CCXV. Hydrangeaceæ.
Trees or shrubs, with opposite leaves, compound or simple, with stipules between the leaf stalks; calyx four or five cleft; petals, four, five; stamens perigynous; styles distinct.	CCXVI. Cunoniaceæ.
Trees, with coriaceous, alternate, simple leaves; flowers green, no axillary umbels; consolidated styles; many-leaved calyx; no albumen.	CCXVII. Brexiaceæ.
Herbaceous, rarely shrubby, exogens, branches quadrangular, leaves opposite; flowers entire, solitary or clustered; calyx tubular, with petals on the margin; and consolidated style.	CCXVIII. Lythraceæ.

The SAXIFRAGACEÆ, derived from *saxum*, "a stone," and *frango*, "I break," from their supposed virtues as a specific in calculus, are characterised by a calyx free or united to the ovary and divided into five segments, a corolla of five petals, ten stamens, awl-shaped filaments, and roundish anthers. Of the species twenty-four are British, most of them true rock plants, many of them old favourites, as *S. umbrosa* (London Pride, None so Pretty, and other popular synonyms), usually made an edging plant in old cottage gardens. They also abound in North America, and Professor Martins found them with other old favourites on the rocky declivities of North Cape. The CUNONACEÆ are of frequent occurrence in Australia, beyond the tropics, and at the Cape of Good Hope. *Cunonia capensis* is in great request for its timber, which is called Red Alder, or Rood Els. The Hydrangeas are met with in Northern India, Japan, and North America.

RHAMNALS.

Perigynous exogens, in which the corolla becomes monopetalous; the flowers monodichlamydeous; carpels consolidated; fruit capsular, berried, or drupaceous, and definite seeds.

Shrubs, with leaves opposite, imbricate, non-stipulate; flowers terminal, apetalous, and axillary, usually red; ovary of four capsules; tubular calyx; and rudimentary cotyledon.	CCXIX. Penæaceæ.
Trees, with tough bark and smooth branches, alternate or opposite leaves, apetalous flowers, ovary of two carpels, tubular calyx, and definite divisions.	CCXX. Aquilariaceæ.
Trees or shrubs, leaves rough, alternate, usually deciduous; apetalous flowers; ovary of two carpels; calyx irregularly divided at the edge.	CCXXI. Ulmaceæ.
Trees or shrubs, sometimes spiny; leaves simple, alternate, rarely opposite; flowers polypetalous; calyx valvate; stamens opposite the petals; and erect seeds.	CCXXII. Rhamnaceæ.
Trees or shrubs with alternate leaves with two stipules; flowers small, axillary polypetalous; calyx valvate; stamens alternate with petals; seeds pendulous.	CCXXIII. Chailletiaceæ.
Climbing shrubs, with opposite leaves, simple, entire, or toothed and coriaceous; flowers polypetalous; calyx imbricate; stamens three, monodelphous.	CCXXIV. Hippocrateaceæ.
Small trees or shrubs, with alternate leaves, seldom opposite; simple, small stipules; flowers polypetalous; calyx imbricate; stamens inserted in the disc, alternate with the petals.	CCXXV. Celastraceæ.
Herbaceous exogens, sometimes shrubs, with simple leaves, polypetalous flowers, and episepalous stamens.	CCXXVI. Stackhousiaceæ.
Trees or shrubs of the tropics, leaves alternate, non-stipulate: flowers monopetalous; epipetalous stamens; ascending ovules and short radicle.	CCXXVII. Sapotaceæ.
Trees or shrubs, with alternate leaves, non-stipulate; toothed monopetalous flowers; stamens epipetalous; part of the ovules suspended leafy cotyledon.	CCXXVIII. Styracaceæ.

Plate XVII.—The Common Elm (*Ulmus campestris*)

These orders consist of evergreen shrubs, trees, and herbaceous plants, which are, with few exceptions, confined to the tropics of both hemispheres and the warmer parts of Europe. The exceptions are the ULMACEÆ, or Elms, which have usually been classed among the Urticaceæ, from which Mirbel has separated them, in which he has been followed by Dr. Lindley. They differ from Urticaceæ in having a two-celled fruit and hermaphrodite flowers.

The Elm (*Ulmas campestris*) (Pate XVII.) is generally found in mountain woods, and it is not uncommon to find it planted by road-sides and in places of public resort. It is a large tree, with branchless stem; a cone-shaped head, formed of strong ascending branches, abundantly furnished with close, compact, and regularly distichous boughs. Its leaves are alternate, furnished with two caducous stipules, oval, acute, and irregularly oblique at the base; doubly dentate, and generally pubescent and rough. They only appear after the flowers, which are reddish, and arranged in sessile fascicles, or bundles. Each flower, always without corolla, consisting of a calyx of four or five lobes, with four to five stamens opposite to these lobes, having bilocular anthers, opening from without by five longitudinal clefts; a free, two-celled ovary, containing a single anatropal ovoid. The fruit, or samara, of the Elm (Fig. 422) is dry, compressed, largely winged, membranous in all its circumference, hollow at the summit, indehiscent, and unilocular.

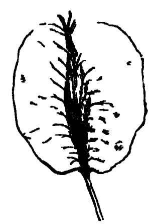


Fig 422. Samara of the Elm.

The various species of Elm are found wild in most parts of the world. They are trees or shrubs of the North of Asia, of the mountains of India, of North America, China, and Europe. There is a peculiarity belonging to the seeds of the Elm; they do not produce trees precisely like the parent tree, the difference being so considerable as to have led, as most botanists think, to the multiplication of species in cases where this variation alone caused the difference. This very peculiarity, however, renders the Elm a favourite object in ornamental planting. The Common Elm is represented in Plate XVII.

The *Rhamnaceæ*, *Sapotaceæ*, and *Styracaceæ*, belonging to this group, produce medicinal plants of considerable importance. The berries of various species of Rhamnus are violent purgatives; some

of them yield excellent dyes, others are grateful condiments. Among the *Styracaceæ*, which are, with some few exceptions, natives of the tropics, we find many useful properties. Storax and benzoin, the produce of *Styrax officinalis* and *S. benzoin*, are astringent and aromatic: the former, a native of Syria, but now found in the Levant, Italy, and Spain; the latter is found in the islands of the Indian Archipelago.

GENTIANS.

Perigynous exogens, with monopetalous flowers, having a minute embryo and much albumen, which separates them from Solanals, and parietal placentæ, which distinguishes them from Cortusals.

Trees or shrubs, with alternate non-stipulate leaves; axillary inflorescence; flowers hermaphrodite; stigma simple, radiating.	CCXXIX. Ebenaceæ.
Evergreen trees or shrubs, branches often angular, leaves alternate or opposite; non stipulate flowers, small, green or white; stigma at the end of a style.	CCXXX. Aquifoliaceæ.
Trees or shrubs, with non-stipulate leaves; corymbose inflorescence; stigma collected into a massive head.	CCXXXI. Apocynaceæ.
Herbaceous plants, shrubs, or trees, with opposite entire leaves, usually with stipules intervening; flowers racemose or solitary.	CCXXXII. Loganiaceæ.
Under-shrubs, with densely imbricated non-stipulate leaves; stigma at the end of a style; flowers solitary and terminal; petals five, unequal, stamens five, equal and interpetalous.	CCXXXIII. Diapensiaceæ.
Shrubs, with entire, narrow, rigid, non-stipulate leaves, in whorls, articulate at the base; flowers in dense spikes; calyx tubular and campanulate; corolla monopetalous; stamens equal in number to the segments.	CCXXXIV. Stilbaceæ.
Herbaceous leafless parasitical plants, non-stipulate; flowers didynamous: calyx inferior; persistent corolla; monopetalous stamens; four anthers; one-celled stigma, simple, at the top of a style.	CCXXXV. Orobranchaceæ.
Herbaceous plants, rarely shrubs, sometimes twining; leaves opposite, non stipulate, sessile; flowers regular, terminal, or axillary: calyx inferior, persistent; corolla monopetalous; stigma at the summit of a style.	CCXXXVI. Gentianaceæ.

The Gentian group range over the entire globe. They bloom on the verge of eternal snow in the Alps, in the chinks of the rocky steeps of North Cape, in the Himalayas, on Mexican mountains, and in the hottest sandy plains of India and South America. As ornamental plants, they are remarkable for the brilliant colours and beautiful form of their flowers, whose prevailing colours are either an intense blue or a clear bright yellow.

The EBENACEÆ are Indian and tropical, although a few species are found as far north as Switzerland in the Old World, and New

York in the New. They are chiefly remarkable for their hard black wood, sometimes variegated, and known as Ebony and Ironwood; also for the extreme acerbity of their unripe food.

The AQUIFOLIACEÆ, which include the Common Holly, are found sparingly in the West Indies and South America, where *Ilex Paraguayensis* yields the Paraguay tea, in the leaves of which Mr. Stenhouse detected theine.' The evergreen shrub, *Prinos glabra*, is employed as a substitute for tea in many parts of North America. In Europe the Common Holly (*Ilex aquifolium*), with its numerous varieties of gold and silver-blotched, broad, narrow, and thick serrated leaves, is a beautiful object in ornamental clumps of shrubberies, especially when clothed with its profusion of red or yellow berries.

The APOCYNACEÆ, or Dogbanes, are trees or shrubs, chiefly tropical, *Vinca* and *Apocynum* alone belonging to temperate climates. For the most part, they are handsome plants, with large, showy, symmetrical flowers. They all yield a milky juice by incision in the stem, which is generally poisonous. The Taughin poison tree of Madagascar, which was at one time used as an ordeal of guilt or innocence, is remarkable for its poisonous properties. In the Periwinkle (*Vinca minor*), the calyx (Fig. 423) is five-parted, while the root, like that of the Gentians, is bitter, acrid, and astringent. Others are not only harmless, but nourishing; the *Hya-Hya*, or Milk-tree of Demerara, and cream-fruit of Sierra Leone, are of this description. Caoutchouc is yielded in abundance by *Vahea gummifera*, *Urceola elastica*, and *Willughbeia edulis*. Many of them yield valuable medicines, but from the great prevalence of the poisonous properties in the order they require to be administered with caution. Even the Oleander (*Nerium*) is a formidable poison, as well as a destroyer of cutaneous vermin. It is related that while the French troops occupied Madrid, a marauding soldier cut some branches of *Nerium oleander* to employ as spits on which to roast his plunder, and of the twelve comrades who partook of the feast seven died, and the other five were dangerously ill.

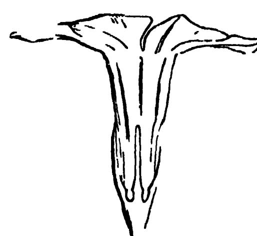


Fig. 423. The Periwinkle (*Vinca*).

The LOGANIACEÆ, separated from the former order, are either tropical or near the tropics, a few species belonging to Australia and America. There is no order more venomous than this, which now includes *Nux vomica*, a drug yielded by the seeds of *Strychnos Nux vomica*, an Indian tree, with small greenish-white flowers, ribbed leaves, and a beautiful round orange-coloured fruit, the size of a small apple, having a brittle stalk and white, gelatinous pulp. The pulp of the fruit, according to Roxburgh, is perfectly harmless, and is greedily devoured by birds, but the seeds are extremely dangerous.

The other members of the group have few properties worth mentioning; the OROBRANCHACEÆ are parasites upon the roots of other plants. The seeds, according to Vaucher, will be dormant until they come into contact with the roots of the Hemp, the plant on which it grows parasitically, when they immediately begin to germinate.

The GENTIANACEÆ belong to the monopetalous exogens of De Candolle and Jussieu; they are herbaceous plants, ribbed leaves, imbricated corolla, stamens and petals, alternate ovary, superior two-celled, standing right and left of the axis of growth. As an example of the order we shall limit ourselves to describing the Little Centaury (*Erythræa centaurium*), Fig. 425.

Fig. 424

Fig. 425.—Erythræa Centaurea.

It is a little plant, common in woods, fields, and glades; its opposed leaves are entirely sessile, and disposed like the thyme. The flowers are regular and hermaphrodite; the calyx tubular, with five linear divisions. The corolla is in the shape of a funnel, with very long tube and limbs, with five divisions. Five stamens

are inserted upon the tube of the corolla, and the anthers open from within by two longitudinal clefts. Before the expansion of the flower they are straight, but become spirally gyrose after the emission of pollen. The pistil is composed of a superior ovary, surmounted by a filiform style, divided into two branches, which are rounded at the summit. The ovary is uniocular, and encloses a parietal placenta, bearing a great number of anatropal ovules. The fruit is a capsule opening in two valves, which bear the seeds upon their sides. These enclose a very small embryo in a fleshy albumen.

The Gentians (*Gentiana*) only differ from the preceding in the secondary characteristics drawn from the shape of the ovary, the placenta, and stamens.

The root of the Yellow Gentian (*G. lutea*) is employed in medicine, being the plant which furnishes the Gentian root of the druggists. It is a native of the Alps and other mountains of Central Europe, growing vigorously in calcareous soils, where its numerous bright yellow flowers, in bundles and verticles, surprise the traveller by their unexpected appearance.

Most other species of Gentians are now abandoned in medicine; but botanists cherish them for their elegance of form and the brilliant colouring of their flowers. We may cite as belonging to this family two of the most graceful ornaments of our rivers and ponds: the Marsh Trefoil (*Menyanthis trifoliata*), whose trifoliate leaves and flowers, disposed in spikes, snowy white, rose-coloured or purple in their tints, are furnished on the inside of their corolla with delicate filaments, rolled up from within, and of a dazzling whiteness. Again, there is the Fringed Buckbean (*Villarsia nymphoides*), the elegant rival of the Nuphars; which is being introduced into our ornamental waters, where their dark green leaves, and white, yellow, or orange-coloured flowers form a very graceful ornament.

SOLANALS.

Perigynous exogens, grouped together by the common characters of a monopetalous corolla; axile placentæ; symmetrical flowers; two and three-celled fruit, with large embryo, surrounded with small albumen. Anomalous genera, having no corolla or

separate petals, occur, but they are rare. Lateral affinities occur, which render the separation of the various groups a subject of very minute discrimination.

Trees or shrubs, with opposite, sometimes pinnate, leaves, on dichotomous branches; flowers in terminal or axillary racemes or panicles; calyx inferior; corolla hypogynous; four-cleft stamens, two or four, free.	CCXXXVII. Oleaceæ.
Herbaceous plants or shrubs, with alternate undivided or lobed leaves; calyx five-parted; inferior corolla, monopetalous, five-cleft; stamens five, free; axile placentæ; embryo ternate.	CCXXXVIII. Solanaceæ.
Shrubs or herbaceous, often twining, plants; leaves entire, opposite, alternate, or whorled; ciliæ in lieu of stipules; flowers in umbels; calyx five-parted; corolla monopetalous; stamens five, inserted in its base; anthers and stigma consolidated into a column.	CCXXXIX. Asclepiadaceæ.
Trees with alternate leaves, scabrous, non-stipulate; flowers in panicles; calyx inferior; corolla monopetalous; stamens five, free; axile placentæ; leafy cotyledon, folded longitudinally.	CCXL. Cordiaceæ
Herbaceous plants or shrubs, usually twining; smooth or simply pubescent leaves, alternate, non-stipulate; flowers axillary; corolla monopetalous; stamens five, free, inserted in the base of the corolla; doubled up leafy cotyledon.	CCXLI. Convolvulaceæ.
Leafless colourless parasites, with flowers in dense clusters; calyx inferior; corolla persistent; stamens equal to segments of the corolla, free.	CCXLII. Cuscutaceæ.
Herbaceous plants, opposite, occasionally alternate leaves; calyx inferior; corolla regular; five-lobed stamens, free, five inserted in tube of corolla; axile placentæ; straight cotyledons.	CCXLIII. Polemoniaceæ.

This important and numerous group includes a vast number of useful plants. Among the OLEACEÆ we have the Common Olive, whose fruit and oil are alike valuable. The Ash (*Fraxinus*) is extremely abundant both in this country and America, and over the whole of Europe, the sap generated between the bark and the wood of *Fraxinus rotundifolia* yielding the manna of the druggists. In the warm climates of Southern Europe this substance, which is a distinct principle called "mannite," is also produced from the Common Ash (*F. excelsior*). The Lilac (*Syringa vulgaris*) is also known to possess valuable febrifugal properties.

The Lilac, Olive, and Ash trees are the most interesting plants of the Oleaceæ. Lilacs have regular and hermaphrodital flowers; their monosepalous calyx is four-lobed; corolla four-cleft, monopetalous, hypocrateriform, the tube of which is much elongated, and surrounded by a spreading, four-lobed limb; two stamens, having bilocular anthers opening from without by two longitudinal clefts, are inserted upon the tube of the corolla. The pistil is composed of a superior ovary, surmounted by a style divided into two stigmatic branches. This ovary is two-celled, each cell containing two suspended anatropal ovules. Fruit, a drupe,

a berry, or a capsule, the latter opening into two valves, having a partition in the centre, and only containing one seed by abortion. They are provided with a fleshy albumen and with a straight embryo.

The Lilacs were originally from Asia. Their leaves are opposite and simple. Two species are cultivated in our gardens: the Common Lilac (*Syringa vulgaris*) and the Persian Lilac (*Syringa Persica*); both of them bitter, but without acridity, and useful febrifugals.

The Olive (*Olea Europæa*) is a tree of middle size, from twelve to twenty feet high, of a sober greyish green aspect, and without beauty, having a rugged stunted appearance. Its leaves are oblong, or entirely lanceolate; the upper surface smooth and whitish green, the lower scaly. The flowers of this tree form axillary bunches, straight and pendent during efflorescence, drooping when at maturity. Its fruit is a drupe, with unilocular stone produced by the abortion of one cell. The pericarp of this drupe contains a fixed oil holding the highest rank among oils used for alimentary purposes, which is obtained by pressure. In November, when the fruit is quite ripe, and assuming a reddish colour, it is gathered, taken to the mill, and passed between two grinding stones, placed at such a distance as to crush the fleshy part without breaking the stone; the fleshy part and the stones being thus separated, the former mass is put into bags made of rushes, and moderately pressed. What is called "virgin oil" is thus obtained; the pulp is moistened with water and again submitted to pressure, and the ordinary oil of commerce is obtained, the quality varying according to the number of times the pulp is watered.

The Privet (*Ligustrum vulgare*) is, like the Olive, nearly allied to the Lilac. Its leaves are astringent, and the berries, which the birds eat, furnish a black colour used in dyeing. Country people in France manufacture a writing ink with the crushed fruit of the Privet.

The Ash (*Fraxinus*) also belongs to the same family. To understand the structure of the Ash, let us examine the structure of two species, namely, the Flowering Ash (*Fraxinus ornus*) and the Common Ash (*F. excelsior*). The former is a tree from thirty to forty feet in height—a very ornamental tree.

Growing almost spontaneously in the South of France, it is cultivated as an ornamental tree in most countries. The composite leaves of the Flowering Ash have from seven to nine sessile, lanceolate and dentate folioles; they are green and smooth on the upper surface, the lower part a little paler, and barbate throughout the whole length of the midrib. The flowers appear with the leaves; they are regular and hermaphrodite, and of a greenish white. The calyx is four-lobed, and the whitish corolla has four very long linear petals. There are two stamens and one pistil, with two cells each, containing two suspended anatropal ovules, like the lilac; the fruit a winged samara.

From this and some other species of the Ash—notably, as already observed, from *F. rotundifolia*—a liquid is drawn from it by incisions made in the bark, which concretes when exposed to the air. It is known under the name of "manna," and seems to be a principle in itself, being incapable of fermentation. When fresh, it is sweet and nutritious; with age it becomes slightly purgative, and serves a useful purpose in medicine. The most highly esteemed manna is obtained from Sicily. It is furnished by different species of the Ash, especially the species named.

The Common Ash (*Fraxinus excelsior*) (Plate XVIII.) is a large tree, which when in good condition reaches the height of seventy or eighty feet, with a trunk of eight or ten feet in circumference. It grows in the woods, in clumps, or by itself, blossoming in April and May. Its leaves present from nine to fifteen nearly sessile, lanceolate, opposed folioles, smooth on the upper part, velvety below, at the base of each side of the midrib. The flowers of the Common Ash, contrary to those of the Flowering Ash, are completely destitute of envelopes; they are composed of two stamens and a pistil. The flowers and the fruit resemble those of the Flowering Ash (*Fraxinus ornus*).

The Common Ash is found in many parts of Northern Asia, and is said to be indigenous in Japan. Its rapid growth and tough, hard wood make it one of the most useful British trees, besides being singularly graceful as an ornament on lawns and parks; but more especially does it seem the natural ornament of architectural ruins, such as Melrose or Netley abbeys, where it may be seen in great perfection, blending its slender branches

Plate XVIII.—The Common Ash (*Fraxinus excelsior*).

and airy foliage with the venerable walls and tracery of the windows.

The Ash, however, is an enemy to all interloping vegetation; its rapid growth exhausts the soil of all organisable substances, and the extension of its roots may be traced in the languid growth of its vegetable neighbours.

The Weeping Ash (*F. pendula*) has all the characters of the Common Ash, while the tendency of its branches is to bend downwards, so that the arching boughs, when grafted on a stem of suitable height, will soon reach the ground, and form a natural arbour. Probably *F. excelsior*, if weighted at the extremity of the branches, would have the same tendency.

The SOLANACEÆ, or Nightshades, are natives of all parts of the world without the polar circle, but they culminate in number and energy in the tropics. At first sight it would seem an anomalous system which places the Potato and the Love Apple in the same order with the Deadly Nightshade and Henbane; but, as De Candolle remarks, "it is not to be lost sight of that all our food should include a modicum of an exciting principle, which if it existed in greater quantity would be injurious, but which in moderate proportions is only a natural and necessary condiment." Besides, as Dr. Lindley says, the apples, or fruit, of the potato are narcotic, although the tubers are wholesome and nutritious when cooked. Many plants of this order are used in medicine, Henbane (*Hyoscyamus*), Deadly Nightshade (*Atropa*), Bitter-sweet (*Solanum*), Stramonium (*Datura*), and Tobacco (*Nicotiana*) being the chief and most valuable.


Fig. 426.—Potato Blossom.

If we examine the Potato (*S. tuberosum*) as a type of the family, we find the calyx (Fig. 426) is monosepalous, with five divisions; the corolla monopetalous, and shaped like a wheel or cup, having lobes alternating with the division of the calyx, five stamens with short filaments, and bilocular anthers, opening at the summit by two spores. The pistil consists of a superior ovary, surmounted by an elongated style, which terminates in an

obtuse stigmata. This ovary has two cells, and for each cell a large placenta, lobed, with one atropal ovule inserted upon the partition which separates them. The fruit is a berry or apple, containing a number of compressed seeds, supplied with a fleshy albumen and an embryo bent round upon itself.

Fig. 427 —Potato plant and tubers.

The *Solanæ* are plants with simple alternate leaves without stipules, the stems of which are herbaceous, ligneous, or sub-ligneous, and the inflorescence is indefinite.

The *Tuberous Morell* (which has also been called *Solanum tuberosum*), of which we have been writing, is better known as the *Potato* (Fig. 427). This useful vegetable came originally from

the Cordilleras of Peru and Chili. We have already said that its tubers are not the roots, but the real subterranean branches of the plant: P (Fig. 428) being the parent tuber, from the evolution of an eye of which the axis or under-ground stem A has issued; *a* is a branch given off at a node of the primary axis A, at which also the root-fibres *r* are developed; T, a young tuber, is the

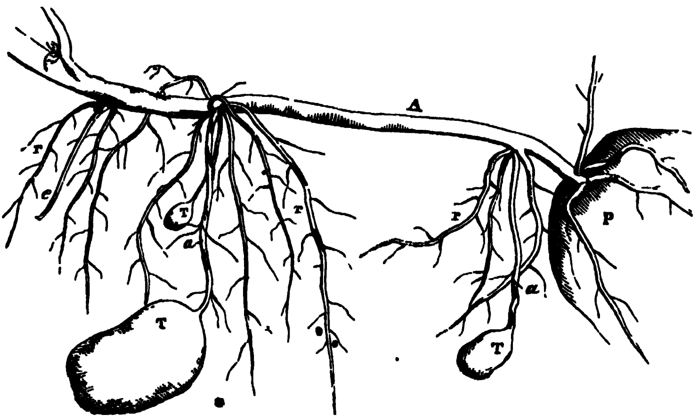


Fig. 428. Roots and Tubers of the Potato.

thickened extremity of the branch. As examples of the genus Solanum, we may also cite the Black Nightshade (*S. nigrum*), and the Woody Nightshade (*S. dulcamara*).

The Nightshade (*Solanum nigram*) is a herbaceous shrubby plant, which grows abundantly under hedges, in woods, by river sides, on the walls of cottages, and in cultivated places. It has white flowers, producing a black berry, while *S. Dalmacara* has purple flowers and purple berries. An active crystallizable principle, vomitive at first, afterwards narcotic, pervades both fruits.

The Egg Plant (*Solanum esculentum*), known as the Mad and Jews' Apple, is a herb originally from tropical Asia, which culture has spread along the shores of the Mediterranean and Southern regions of Europe. It is now naturalised in America. Its large, shiny, ovoid, generally violet, but sometimes yellow-coloured fruit contains a white flesh, which becomes comestible by cooking. The Apple of Sodom (*S. Sodomeum*), a native of South Europe and North Africa, contains a greenish pulp which produces headache, madness, and even death.

Marvellous properties are ascribed to the Egg Plant by ancient writers. Mandeville, an old English writer of wonderful travels, speaking of the Dead Sea, tells us that "besyden growen trees that baren fulle faire apples, and faire of colour to beholden, but whosoe breakethe them or cuttethe them in two, he shall find them within coles and cyndres." Milton, alluding to this tradition, finely apostrophises the breakers or cutters:—

> "They, fondly thinking to allay
> Their appetite with gust; instead of fruit
> Chewed bitter ashes."

The Egg-shaped Morell (*Solanum oviferum*), the fruit of which is the shape, colour, and about the size of a hen's egg, is eaten cut up in slices and fried.

Around the Solanum are grouped many interesting plants which we ought to mention did our space permit.

The Tomato (*Lycopersicum esculentum*) is cultivated in most gardens, and produces a fruit called the Love Apple, of a lively red colour, with round lobes, filled with an orange, sourish pulp, having a very agreeable perfume.

The Belladonna, or Deadly Nightshade (*Atropa belladonna*), is a perennial herbaceous plant, of elegant carriage, but suspected physiognomy, with sombre leaves, livid flowers, and fruit resembling little black cherries. The sweet flavour of these fruits is deceitful, for their juices constitute a deadly poison. In some circumstances the medicine drawn from the berry (Fig. 429) has powerful narcotic and soothing properties. The expressed juice of the leaves produces a remarkable dilation of the pupil of the eyes—a singular property which has been utilised in operations for cataract to facilitate the extraction or lowering of the crystalline. The juice of the berry applied as a cosmetic pales the cheek.

Fig. 429.—Berry of Belladonna.

The Mandrake (*Mandragora officinarum*), the properties of which are analogous to those of Belladonna, but less violent, in olden times, was employed by pretended magicians and false sorcerers to produce mental hallucinations and disturb the reason. The

Winter Cherry (*Physalis alkekengi*), a slightly acid succulent berry, enclosed in an accrescent calyx, sometimes used at dessert, is recommended as a diuretic. The *Capsicum*, the shiny berries of which are green at first, and red when arrived at maturity, contains a resinous, balsamic, but very acid principle, which makes these fruits to be much esteemed as a condiment in all countries.

Tobacco (*Nicotiana*) belongs to another section of the family of the Solanaceæ. Their anthers open by two longitudinal clefts. Their fruit is dry; it is a capsule which opens in two valves, leaving the placentary partition filled with seeds in the centre. (Fig. 430.) The Tobacco is a renowned plant, which has made the conquest of the world. In all parts of the globe it is consumed. This, however, is not the place to enlarge upon this subject.

Fig 430 —Tobacco Plant.

Henbane (*Hyoscyamus niger*) is distinguished from the Solanum and its congeners as well as from the Tobacco, by its capsular fruit, which opens circularly like a little box. Lastly, we must mention the Thorn Apple (*Datura stramonium*), the incomplete madricular capsule of which is generally filled with prickles or tubercles.

The ASCLEPIDIACEÆ are succulent plants, chiefly of South Africa, where they flourish in the dry and sterile soil. In tropical India, America, and Australia, they also abound; only two species being found in northern regions. Of *Asclepias* there are many North American species, and *Cynanchum* is found between 59° and 32° north latitude. The roots of most of the species are acrid and yield a milky juice. Most of them possess useful medicinal properties.

The CORDIACEÆ are native trees of the tropics of both hemispheres. The flesh of their fruit being succulent, mucilaginous, and emollient.

The CONVOLVULACEÆ, or Bindweeds, are familiar to most readers,

and universal favourites, from their elegant twining stem, which accounts for their name—derived from *volvo*, to wind round—heart-shaped or lobed leaves, and the innumerably varied colours of their bell-shaped flowers.

The CUSCUTACEÆ are climbing colourless parasites of both hemispheres. Mr. Griffiths speaks of a gigantic species which even preys upon itself in Affghanistan, where he saw one mass covering a Mellon-tree from twenty to thirty feet high.

PRIMULADS.

Perigynous Exogens, having monodichlamydeous, monopetalous flowers, a free central placenta, and an embryo lying inside a large quantity of hard albumen.

Small trees, bushes, or herbaceous plants, with lobed alternate leaves, the lower ones opposite; flowers in racemes or spikes; calyx inferior; corolla monopetalous; stamens five, alternate with the sepals; two styles.	CCXLIV. Hydrophyllaceæ.
Herbaceous plants or undershrubs, with alternate or clustered leaves, sheathing and non-stipulate; flowers loosely panicled; calyx and corolla tubular, monopetalous, with a narrow tube or five petals with a long claw; stamens opposite the petals; five styles.	CCXLV. Plumbaginaceæ.
Herbaceous plants, leaves in rosettes, flowers in spikes; calyx four-parted; imbricate in æstivation; corolla monopetalous; stamens four, alternate with the petals; one style.	CCXLVI. Plantaginaceæ.
Herbaceous, sometimes almost shrubby plants; leaves radicle; flowers in radical scapes and umbels; calyx five cleft; corolla, monopetalous; stamens opposite the petals, inserted upon the corolla, equal in number to its segments; fruit capsular; one style.	CCXLVII. Primulaceæ.
Trees or shrubs, with alternate leaves, serrated, or entire, coriaceous, smooth; flowers in umbels, corymbs, or panicles, small white or red; calyx four or five cleft; stamens opposite the petals; fruit indehiscent, drupaceous.	CCXLVIII. Myrsinaceæ.

The HYDROPHYLS are little known out of the American continent. *Nama* and *Hydrolea* occur in India; some of the *Nemophila* are garden favourites cherished for their elegant flowers; the PLUMBAGINACEÆ grow in the salt marshes and sea-coasts of the temperate parts of the world, along the Mediterranean basin, others in Greenland and the mountain ranges of Europe, and a few within the tropics; *Plumbago zeylanica* from Ceylon to Port Jackson; the *Ægialitis* grow among the mangroves of Australia; *Vogelia* at the Cape of Good Hope.

The PLANTAGINACEÆ, often stemless herbs, are scattered over the world, but they prevail chiefly in temperate latitudes; their foliage is slightly bitter and astringent; their seeds are covered with mucus, which renders many of them emulcent.

The PRIMULACEÆ are herbaceous plants, with simple alternate leaves, and without stipules; their stems are chiefly subterranean, and their leaves form a rosette at the surface of the soil, from whence springs the stalk bearing the flowers. They are mostly natives of temperate regions, rare between the tropics, but abound-

Fig 431. The Cowslip (*Primula veris*)

ing in mountainous parts of Europe and Asia. The Cowslip (*Primula veris*), Fig. 431, grows in our woods and fields. The farinaceous or Birds' Eye Primrose is not uncommon in boggy places as far north as Yorkshire. The Grandifloral Primrose is

an indigenous species in France, often cultivated in gardens; its flowers are of various colours, yellow, purple, and white. The Chinese Primrose makes an agreeable ornament to our conservatories during the winter.

The calyx of the Primrose flower is monosepalous, and forms a tube terminated at the summit by five lobes or teeth. The corolla is monopetalous and hypocrateriform; its limbs present five lobes alternating with the teeth of the calyx; five stamens are inserted upon the tube of the corolla, and their two cells open from within by two longitudinal clefts. The pistil presents a superior ovary, surmounted by a more or less elongated style. The ovary is unilocular, and has in its interior a large central placenta: it is filled with a great number of ovules. The fruit is a capsule, with five valves, opening at the summit, through which the seeds, which are supplied with a fleshy albumen enveloping a straight embryo, are suffered to escape.

Next to the Primrose we will place the Cyclamen, so characterised from its elegant corolla with reflex lobes, and by its subterranean stem, for it has no cereal stem, the root stem being sometimes so enlarged as to resemble a loaf of bread; it is a favourite food with swine, whence the name of Sow's Bread, not uncommonly given to it. We have also *Lysimachia*, with wheel-shaped corolla, and bitter astringent roots; one of them, the Yellow Loosestrife (*L. vulgaris*), unfolds its large handsome flowers by the sides of rivers and in shady watery places.

Slightly removed from the Primroses are the Pimpernels (*Anagallis*); they have a round ovary, with a thread-like style, one a capsule, opening like a box with a lid.

The remaining Perigynous orders, ranging from CCXLIX. the Jasminaceæ, to CCLXV. the Lentibulariaceæ, although they include some interesting families of plants, our space compels us to dismiss with little more than a brief enumeration. In this group we must include the *Jasmines*, chiefly inhabitants of tropical India, America, and Australia, two species only being natives of the South of Europe.

Shrubs, erect or climbing; leaves opposite; flowers hermaphrodite, in corymbs or panicles, frequently sweet-scented; corolla hypogynous, four to eight lobed; stamens two, inserted in the tube of the corolla; style simple.	CCXLIX. Jasminaceæ.

Small trees or shrubs, with opposite leaves; minute panicled flowers; calyx with four sepals; corolla four-cleft; stamens four; fruit a berry, one-celled. Found chiefly in India, Syria, and North Africa.	CCL. Salvadoraceæ.
Trees, shrubs, or herbaceous plants, harshly pubescent, with simple leaves; solid four-celled ovary; terminal style; and berry-like unopening fruit. Natives of tropical countries and the South of Europe.	CCLI. Ehretiaceæ.
Prostrate herbaceous or sufrutuose plants, with alternate non-stipulate leaves; showy symmetrical flowers; monopetalous corolla; fruit enclosed in a permanent calyx.	CCLII. Nolanaceæ.
Herbs, shrubs or trees, with simple alternate leaves, often hairy; flowers hermaphrodite; circinate calyx; five, rarely four-parted, corolla; hypogynous stamens five, inserted in the corolla; stigma naked.	CCLIII. Boraginaceæ.
Herbaceous stemless plants, with radicle leaves; flowers regular and symmetrical on scapes; fruit, a solitary nut. A single genus of New Holland forms the order.	CCLIV. Brunoniaceæ.
Herbaceous plants or under-shrubs, with square stems; opposite non-stipulate leaves, replete with receptacles for aromatic oil; calyx tubular; corolla monopetalous; stamens four, inserted upon the corolla; irregular unsymmetrical flowers.	CCLV. Labiaceæ.
Trees or shrubs, sometimes herbaceous plants, with opposite non-stipulate leaves; flowers unsymmetrical, in opposite corymbs or alternate spikes, sometimes in dense heads; calyx tubular; corolla hypogynous; fruit a nut, sometimes a berry.	CCLVI. Verbenaceæ.
Shrubs, with simple non-stipulate leaves; flowers irregular, unsymmetrical; corolla monopetalous; stamens four; fruit a drupe.	CCLVII. Myoporaceæ.
Herbaceous plants or branching shrubs, with alternate leaves; spathaceous calyx; corolla tubular, hypogynous; stamens four, didynamous; fruit a two-celled nut.	CCLVIII. Selaginaceæ.

The Boraginaceæ are mostly natives of temperate regions. These plants are abundant in Southern Europe; their properties are unimportant. The Bugloss and the pretty Forget-me-not (*Myosotis palustris*) being, perhaps, the best known species.

The common Comfrey (*Symphitum officinale*), Fig. 432, which we will take for a type of this family, is a herb angular, rough, heavy, with simple alternate leaves, without stipules; the very ample radicle leaves are ovately-pointed, or lengthily petiolate; the cauline leaves decurrent lanceolate, with rough and pubescent limbs. The inclining flowers, disposed in cymes, are very large, white, yellow, or violet coloured; they are regular and hermaphrodite. The calyx has five lanceolated sepals. The corolla is tubular, with campanulate urceolated limbs, and short triangular lobes, reflex on the outside. Underneath these five lobes the neck is furnished with five lanceolated scales, forming a flat white cone, the sides of which are filled with transparent crystalline papillæ. Five stamens are inserted upon the tube of the corolla, and alternate with its lobes. The fruit is composed of four achenæ. The Comfrey is common in England, growing in meadows, near rivers and ditches.

By the side of *Symphitum* are grouped other genera very like them, such as the Borage (*Borago officinalis*), the rose-like corolla of which, purple in the bud, becomes of a very pretty blue when fully expanded; the Bugloss (*Anchusa officinalis*), sometimes

Fig. 432.—The Comfrey (*Symphitum officinale*).

called Ox-tongue, a common plant in waste places, the juice of which was formerly in request as a cordial; *Pulmonaria officinalis*, employed in olden times in medicine, now abandoned to the kitchen in the north of Europe, where it is used as a culinary vegetable; the *Myosotis*, which from its pretty blue colour and from its beauty and freshness has obtained the name of Forget-me-Not; the Viper's Bugloss (*Echium vulgare*), chiefly

remarkable for the strange irregularity of its corolla, and the unequal length of its stamens.

The LABIATEÆ, from *labium*, lipped, describes the peculiar form of the upper lip of the corolla in this important order. They are herbaceous, or half shrubby plants, usually yielding more or less quantities of aromatic essential oil. Their stems are four-sided, with opposite branches and leaves; flowers in axillary opposite clusters, sessile, or on short stalks; and the upper lip of the corolla, which is characteristic of the order, consists of two united petals opposite to the three united sepals of the bilabiate calyx, while the two united sepals are opposed to the three united petals of the corolla.

The extent of the order has led to various attempts to class them in tribes; of these attempts we select the following :—

TRIBE I. MENTHOIDEÆ. Mint tribe; lobes of the corolla nearly equal.

TRIBE II. SALVICEÆ. The Sages; corolla two-lipped; stamens two; and three lobes separated by a filiform connection.

TRIBE III. THYMOIDES. Thymes; corolla two-lipped; stamens four, nearly equal, or lower pair slightly longer; in true Thymes stamens straight, diverging; in Melissa, stamens more or less bent, converging.

TRIBE IV. LAMIOIDEÆ. Lamium tribe; stamens four, contiguous and parallel under the upper lip of the corolla. In *Nepeteæ* the stamens on the lip shorter than the stamens on the helmet. In the *Stachys* longer. In *Scutellaria* the calyx is two-lipped when the carpels are ripe.

TRIBE V. AJUGOIDEÆ. The Ajugas; upper lip of the corolla short or absent.

The Labiateæ are spread over the whole world, but are most abundant in temperate regions, diminishing in number towards the poles and the tropics; between the tropics they are rare, and from polar regions of both hemispheres they are wholly absent.

The White Dead Nettle (*Lamium album*) (Fig. 433) is a herbaceous plant, frequently met with in grassy places and by road-sides. It will serve as a type of the numerous family of the Labiateæ.

The stems and branches of the Dead Nettles are four-sided; the leaves simple, ovate, and opposite, long and acuminate, unequally dentate and slightly rugose. The inflorescence is composite, in small contracted cymes, with sessile flowers, thus forming what Botanists call *glomerules*, which spring from the axilla of the upper leaves. The flowers are hermaphrodite and irregular. The calyx is monosepalous. The corolla rather large, white, tinged with yellow inside, monopetalous, and bilabiate. The

stamens are four in number, of unequal length, two large and two small, inserted upon the corolla. The pistil consists of a superior ovary, the external and upper surface of which presents

Fig 433 —The White Dead Nettle

four protuberances, and a style, which is inserted in the midst of them, terminating in two branches covered with stigmatic papillæ; each protuberance is a cell of the ovary, and each cell

contains an anatropal ovule; when at maturity, each cell becomes an achene. The seed encloses a straight embryo surrounded by a fleshy albumen, slightly developed.

All the Labiateæ possess similar characteristic organs of vegetation to those described, with some slight differences, depending on the shape of the calyx, that of the corolla, or the number and relative dimensions of the stamens. For instance, the Sages and Rosemaries, instead of having a calyx with five equal or nearly equal teeth, have a bilabiate calyx. They are campanulate or infundibuliform in shape, with nearly equal lobes. The sages have two stamens. These stamens have an anther of a very remarkable structure; the connective is very long, and is placed perpendicular to the filament, like the beam of a balance. At one extremity of this beam is a cell filled with pollen; at the other an appendage which represents the other cell, which is abortive. Most species of the extremely natural family of the Labiateæ are endowed with stimulating properties, due to an essential aromatic oil, which resides in the glands placed under the epidermis. The Common Sage and many other species of the genus are thus gifted; so also is the Rosemary (*Rosmarinus officinalis*), the Wild Thyme (*Thymus serpyllum*), Peppermint (*Mentha piperita*), and the Common Balm (*Melissa officinalis*), from all which useful medicines are obtained by distillation.

The Ground Ivy (*Glechoma hederacea*), the Hyssop (*Hyssopus officinalis*), which are also consecrated to medical usage, are efficacious as bitters and aromatics. The *Teucrium chamædrys* is also sometimes employed in medicine. The bitter principle exists almost exclusively in this plant.

Bignonials,

which conclude the series of perigynous Exogens, have dichlamydeous, monopetalous, unsymmetrical flowers, capsular or berried fruit, consolidated carpels, and embryo with little or no albumen.

Herbaceous plants, leaves opposite or alternate; flowers axillary, solitary or clustered; calyx in five equal parts; corolla monopetalous; parietal placentæ; bony or capsular fruit.	CCLIX. Pedaliaceæ.
Soft wooded, fleshy herbs or shrubs; leaves rugose, non-stipulate; flowers showy, in racemes or panicles; calyx half-adherent, five-parted; corolla monopetalous, tubular; stamens two, didynamous; anthers two-celled, cohering.	CCLX. Gesneraceæ.

Small trees; leaves alternate or clustered; flowers growing out of the old stems or branches; calyx free; corolla monopetalous, somewhat two-lipped; stamens four, growing on the corolla; fruit succulent, hard-shelled.	CCLXI. Crescentiaceæ
Trees, shrubs, and herbs, often twining or climbing; leaves opposite, without stipules; flowers terminal, somewhat panicled; calyx divided or entire: spathaceous corolla; monopetalous stamens, five unequal; winged seeds; no albumen	CCLXII. Bignoniaceæ.
Herbaceous or shrubby plants, with opposite leaves, rarely in fours, without stipules; flowers opposite in spikes, sometimes terminal; calyx four or five-parted; corolla monopetalous; stamens two, both bearing anthers; wingless exalbuminous seed.	CCLXIII. Acanthaceæ.
Herbs, shrubs, or undershrubs, with opposite, whorled, or alternate leaves; flowers axillary or racemose; calyx inferior; persistent sepals, sometimes united; corolla monopetalous; stamens in single series, opposite the sepals; seeds albuminous.	CCLXIV. Scrophulariaceæ.
Herbaceous water or marsh plants; leaves radicle, undivided; flowers single or in spikes; calyx inferior, divided persistent; corolla monopetalous, hypogynous; stamens two, within the corolla; minute seed, without albumen.	CCLXV. Lentibulariaceæ.

The Pedaliaceæ occur in small numbers in the tropics, chiefly in Africa. *Sesasum*, yielding an oil which is substituted for olive oil, and several other species have useful medicinal properties.

The Gesneriaceæ are small bushes, frequently mere herbs, distinguished by their winged seeds, finely oblique veins, sometimes extending into long hairs, or even flattened wings, and the seed a large leafy cotyledon. Those which have forced their way into our gardens are natives of tropical America. Other genera are found in all parts of the world, from the cooler parts of Asia, the Cape of Good Hope, the warm valleys of the Himalayas, and Australia. They are generally trees of great beauty, yielding sweetish fruits.

The Crescentiaceæ, Bignonaceæ, and Acanthaceæ are respectively natives of the tropics of both hemispheres. The Calabash-tree (*Crescentia Cujete*) bears a great gourd-like fruit, filled with a subacid pulp, much eaten by the negroes. The chief station of the Bignonias, whose trumpet-shaped flowers are the glory of the places they inhabit, extends from Pennsylvania to the southern provinces of Chili. The Acanthaceæ, distinguished by their large leafy bracts, which almost conceal their flowers, are almost all tropical, although the typical genera Acanthus is found as far north as Greece, where it became the model for a graceful architectural ornament.

The Scrophulariaceæ include a large number of well-known favourites, of apparently anomalous structure and forms, which at first glance would seem to belong to other orders. They are

ished from the Nightshades by the absence of a fifth stamen, or where the æstivation of the corolla is imbricated. This serves to bring the Petunias into this order. The æstivation of the corolla, and a tendency to lose a part of the stamens, occurs in Verbascum. The tendency of Antirrhinum is to form pouches, or spurs, as in *c*, Fig. 434, in which we observe the corolla taking an upward direction, when the spur is produced which

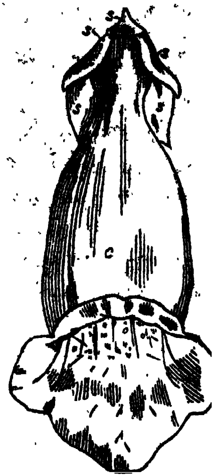


Fig. 434.—The Foxglove (*Digitalis purpurea*). *c*, corolla; *s*, calyx of five sepals.

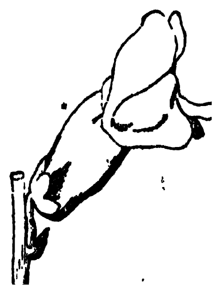


Fig. 435.—Antirrhinum.

causes the Calceolaria to assume the slipper-like appearance; this brings a whole tribe of lovely flowers into the order. The species are generally acrid, bitter, and suspected. In the Foxglove (*Digitalis purpurea*, Fig. 434), and several other species, these qualities become dangerous.

Schizanthus, Calceolaria, Alonsoa, Antirrhinum, Murandia, Lophospermium, Rodochiton, Collinsia, Pentstemon, Russellia, Mimulus, Hemianthus, Digitalis, present us with a galaxy of greenhouse and garden flowers such as scarcely any other order can produce.

Epigynous Exogens.

The term Epigynous—derived from ἐπι, *on*, and γυνη, the *ovary*—alludes to the position of the stamens and other outer floral appendages in respect to that organ. When the stamens are placed on the ovary, their insertion is said to be epigynous, which generally indicates the complete adhesion of the tube of the calyx to the ovary through its whole length, or to the style or disc, as in the case of the Umbelliferæ. This and bi-sexual flowers are the most distinctive mark of this sub-class. It includes many important natural groups and orders, beginning with

The Campanals,

probably the most extensive natural group in the whole Vegetable World.

Herbaceous plants or under-shrubs, with simple, almost always alternate leaves, without stipules; flowers single, in racemes, spikes, or panicles, usually blue or white; calyx superior, five-lobed; corolla monopetalous, inserted into the top of the calyx; stamens inserted into the calyx; ovary two or more celled; free or half-united anthers; naked stigma.	CCLXVI. Campanulaceæ.
Herbaceous or shrubby plants, alternate leaves without stipules; flowers axillary or valvate; terminal calyx; five lobed corolla, irregular, monopetalous, inserted in the calyx; stamens inserted alternately with the lobes of the corolla; ovary two or more celled; anthers syngenesious.	
Herbaceous, rarely shrubby, plants, with scattered, often lobed leaves; flowers distinct, never capitate, calyx superior; corolla superior; stamens five, alternate with the segments of the corolla; ovary two or more celled; anthers free.	CCLXVIII. Goodeniaceæ.
Herbaceous plants or tender shrubs, with scattered, sometimes entire, whorled leaves; flowers in spikes, racemes, or corymbs; calyx adherent; corolla monopetalous, imbricate; stamens two, united with the style into a column.	CCLXIX. Stylidiaceæ.
Annual or perennial herbs, sometimes twining leaves in rosettes; flowers bisexual; calyx superior; ovary one-celled; corolla imbricated; anthers free; ovule pendulous, without albumen	CCLXX. Valerianaceæ.
Herbaceous plants or under-shrubs, with opposite whorled leaves; flowers arranged on a common disc: calyx adherent; corolla monopetalous, tubular, inserted in the calyx; ovary one-celled; anthers free; ovule pendulous.	CCLXXI. Dipsacaceæ.
Herbaceous plants; leaves alternate, non-stipulate; flowers in heads, calyx superior, of five unequal parts; ovary one-celled; corolla valvate; seeds pendulous.	CCLXXII. Calyceraceæ.
Herbaceous plants or shrubs; alternate or opposite leaves, without stipules: flowers unisexual or hermaphrodite; calyx superior; corolla monopetalous, valvate; ovary one-celled; stamens equal in number to the teeth of the corolla.	CCLXXIII. Compositæ.

The Campanulaceæ, or Bell-shaped Flowers, inhabit the temperate parts of the world, being rare in the tropics, and chiefly

found, according to De Candolle, between the 36th and 47th parallel—the chain of the Alps, Italy, Greece, the range of the Caucasus and the Altai Hills: Africa, as far as the Cape of Good Hope, being their true country. The whole order are more or less ornamental, and most of them yield a white milky juice, which is somewhat bitter and acrid. The German botanists divide them into, 1, *Wahlenbergieæ* with capsules opening at the summit, which peculiarity De Candolle found belonged to genera of the Southern Hemisphere; and 2, *Campanulaceæ*, with capsules opening at the side or base, which the same botanist found belonged, with one exception, to the northern part of the globe. Their chief property is the beauty of their flowers.

Fig. 436 —The Bell Flower (*Campanula*).

The Bell Campanula (Fig. 436), so called from its large, full-blown, bell-shaped corolla, opening in great numbers at the same time, is a native of the south of Europe. Its stem is erect, branching towards the top; the leaves are sessile, ovately lanceolate, irregularly crenulate and dentate, with slightly inclined flowers, disposed in loose bunches. The flowers are regular and hermaphrodite. The calyx composed of five sepals; the corolla campanulate, or bell-shaped, is divided in its upper part into five lobes, alternating with the sepals.

The stamens, five in number, are free, and are not inserted in the

tube of the corolla. Anthers bilocular, and the filaments are flattened and enlarged in their lower part in order that they may embrace the ovary. The pistil is composed of an inferior ovary, surmounted by a style, divided into five stigmatic branches. The ovary is five-celled. The fruit a capsule, which opens at the base in five small cells.

There are several species of the Campanula which are only cultivated for their pretty flowers and pyramidal form. We may cite, as worthy of cultivation in the garden, the Peach-leaved Bell-flower (*C. persicifolia*), with flowers of pale blue, erect and in long compound panicles, indigenous in Kent and the south of England and in France. This species grows double, and forms a fine garden flower. *C. pyramidalis* is another stately Bell-flower which reaches the height of three or four feet, forming a pyramidal mass of flower. The pretty Scotch Harebell (*C. rotundifolia*), with slender stem and nodding cluster of "heavenly blue," is not the least worthy of notice.

The LOBELIACEÆ are frequently found within or upon the borders of the tropics of both hemispheres. They are rare in northern parts; Spain, Sicily, and Italy, each claim one, and one is found in Kamtschatka. They are extremely beautiful when in blossom, and great favourites in the greenhouse, but the milky juice with which they are charged is powerfully acrid and narcotic, corrodes the skin, and is fatal taken internally. Burton says that if horses eat *L. longiflora*, inflammation is produced, so that they swell until they burst. Like most of the poisonous orders, it includes species possessing valuable medicinal properties. Many of them yield gums and oils. The Lobeliads are found chiefly between the tropics in the New World; in Asia and Africa they are found to the south of these regions, some few in North America, and one in Kamtschatka. They are all charged with a milky juice which is sufficiently acrid to corrode the skin, mingling with narcotic properties of a dangerous character. The Indian tobacco (*L. inflata*) is a North American species, possessed of medicinal virtues. When dried the plant is formed into a cake, when it has a slightly irritating, acrid taste, somewhat like tobacco, causing a flow of saliva and a feeling of nausea.

The remaining orders of this group are natives of Australia and

the islands of the Indian Ocean. The VALERIANACEÆ are natives of temperate climates; generally strongly-scented aromatic plants The DIPSACACEÆ include the Teazel (*Dipsacus*) used by fullers. The COMPOSITÆ, or ASTERACEÆ, includes an immense number of herbaceous and shrubby plants, sometimes of small trees, amounting to nine thousand species, which botanists divide into Sub-orders, Tribes, and Sub-tribes.

The flowers of this family have an arrangement quite characteristic. They are all disposed on a head or disc, so as to have the

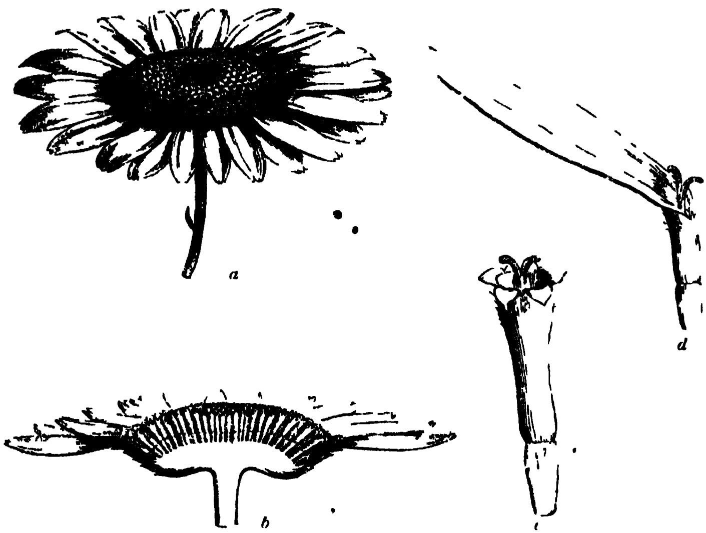


Fig. 437.—Disc, section, and detached flowers of the Daisy.

appearance of being a single flower, though they are really a union of many flowers; hence the name of COMPOSITÆ, which has been given to them. This arrangement is easily understood if we examine the representation of the *capitulum* as it appears in the Common Daisy (*Flora Marguerita*) or *Bellis perennis*, of which we give in Fig. 437 the whole of the capitulum in *a*; a section of the head is seen at *b*; finally, the isolated flowers of the centre, and the circumference of the same capitulum are represented in *c* and *d*. The flowers of the same capitulum may be all of the same description, namely, hermaphrodite, stamened,

and pistilled; or they may also be of two kinds—the exterior neuter or female, the interior hermaphrodite or male. The calyx of these flowers may be of various shapes. Sometimes it is so reduced that it seems as if there were none; in other times it forms a sort of cup or a crown; sometimes it develops into an awn, with teeth and scales. It even degenerates into a kind of silky tuft, which forms an egret. The corolla is either regular or irregular. In the former case it is tubulous, and its limbs generally are five-lobed. In the latter the limbs appear split in its greatest extent, and warped on the outside, like a tongue; dentate at the summit, from whence it separates into two lips. The tubular corolla is called the *floret;* the tongue-like corolla *semi-floret.* The stamens are inserted upon the tube of the corolla, and alternate with its divisions. The filaments are generally free, but the anthers are attached at their edges by means of a tube which sheathes the style. They are two-celled, opening from within. The pistil is composed of an unilocular ovary, containing a single, straight, anatropal ovule; it is surmounted by a very slight style, which is divided into two branches, both in the hermaphrodite and female flowers, but it is undivided in the male. The branches of the style are furnished with stigmatic papillæ, hair-like collectors. Before expansion the style is shorter than the stamens; but at the time of fecundation it increases rapidly, and rises into the hollow cylinder formed by the anthers. As they rise, the hairy collectors sweep off the pollen which the gaping anthers contain, and soon appear charged with its precious dust. It is observed that the female flowers are destitute of hairy collectors; that the male flowers are alike destitute of the stigmatic papillæ and hairy collectors. The fruit is an achene, often furnished with a proper egret, to favour its dissemination. The solitary seed encloses a straight embryo without albumen.

Tournefort separated the Compositæ into *Semifloscules,* namely, those where the capitulum is entirely composed of flowers with a ligulate or semifloret corolla; *Flosculcs,* those in which the capitulum is entirely composed of flowers with tubular corolla, or of florets; and *Radiates,* those where the capitulum is formed of central tubular flowers and of ligulated peripheric flowers.

De Candolle, in his "Podromus," divides the Compositæ into

three grand series. First, *Liguliflorœ*, or *Cichoraceœ*, which have a ligulated corolla, and answer to the Semifloscules of Tournefort. Pappus crown-shaped or chaffy in *Scholymidœ;* seed-nuts without pappus in *Lampanidœ*. Either crown-like or with entire chaffy scales in *Haseridœ;* with narrow, semi-lanceolate, often pinnate scales in *Hypochœridœ*. Naked receptacle and scaly pappus in *Scorzonerideœ*. Receptacle naked or chaffy; pappus hairy, silvery, and fugaceous in *Lactucidœ*. Hairy, rigid, and fragile in *Hieracidœ*. Secondly, the *Labiatœfloræ*, the irregular corollas of which are divided into two lips. Thirdly, the *Tubuliforœ*, the capitulums of which are entirely formed of florets, or provided at the circumference with semi-florets, and which answer to the Floscules and Radiates of Tournefort.

The Liguliforæ, or Cichoraceæ, possess a milky juice, contained

Fig. 438.—Chicory

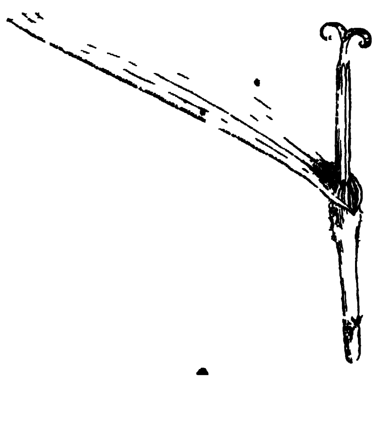


Fig. 439.—Isolated Flower of Chicory.

in a system of lactiferous vessels, which have bitter, resinous, narcotic principles. The properties and virtues of these species vary according to the relative proportion of these, and according to the age of the plants and the development of their different

The Chicory (*Cichorium intybus*) is an indigenous species in France, and probably with us, the roots of which are used in medicine. Fig. 439 represents the wild Chicory; Fig. 439 an isolated flower from the capitulum of this plant. The roots of the cultivated Chicory, dried and roasted, are sometimes mixed with coffee, and are said to mellow its bitterness. The young leaves, dressed as a salad, are eaten by the lower classes in France.

The Endive (*C. endivia*) is a Mediterranean plant, less bitter, and is seldom appropriated to alimentary use, except as a salad.

The wild Lettuce (*Lactuca sativa*) has a bitter juice, of an offensive odour. The cultivated Lettuce yields a juice of which a pharmaceutical extract is obtained by evaporation, called *lactucarium* or *thrictace*, which possesses narcotic properties. It is sometimes employed in medicine as a substitute for opium. The young leaves of the Lettuce, of which many varieties are cultivated in our gardens, are used as salads.

In this same branch of the Composites are the Vipers' Grass (*Scorzonera*), Salsify (*Tragopogon*), and the Dandelion (*Taraxacum*).

The Tubifloral Floscules contain a bitter principle, which gives them stimulating properties. Some of the Carduceæ were held in great favour for medical uses in olden times, but are now abandoned. Such are the Holy Thistle (*Cnicus benedictus*), Milk Thistle (*Silybum Marianum*), Star Thistle (*Carduus calcitrapa*), Corn Blue Bottle (*Centaurea cyanus*), common in France and Switzerland. One of this family, the Safflower (*Carthamus tinctorius*), furnishes a dye soluble in alcohol. It came originally from India, but is now cultivated in Asia, America, and nearly over the whole of Europe. The colour drawn from the Safflower is not very strong, but its shades are very delicate and varied. Mixed with talc it makes a paint which women use by way of rouge. Some of the Carduceæ are comestible. Such are the Artichoke (*Cyanara scolymus*), of which the base of the bracts, the involucrum, and the common receptacle are eaten, while the choke—that is to say, the very young flowers—is rejected; the Cardoon (*Cynara carduncullus*), of which the midrib of the leaves is eaten, being whitened and rendered fleshy by blanching.

The Tubifloral Radiates comprise plants in which a bitter

principle is generally combined with a volatile oil or resin, whilst the roots contain a matter more or less analogous to fecula, somewhat resembling starch, known under the name of *inuline*. According to the proportion of these different principles, some of the species are tonic, others stimulant, others astringent. We may thus mention Wormwood (*Artemisia absinthium*), from which the well-known beverage is obtained; Tansy (*Tanacetum vulgare*); Yarrow, Milfoil, or Thousand Leaves (*Achillea millefolium*); Ptarmicas, of which several Alpine species are used by the Swiss as tea; the different Camomiles, such as the Roman Camomile (*Anthemis nobilis*), of which we give a representation in Fig. 440, an example in which the head has become semi-flosculous by culture; the Mountain Arnica and Elecampane (*Inula helenium*), &c.

Fig. 440.—Roman Camomile.

It is to the large division of the Tubulifloral Radiates that most of the Compositeæ cultivated as ornamental belong. Such are the Chrysanthemums, of which so many beautiful varieties are now cultivated in our town gardens, for which they are especially adapted;

the Field Daisy, and the Golden Daisy. The Astreas are autumnal plants, originally from North America. The Cinerarias and the Gnaphales comprehend many ornamental plants designated under the common name of *Immortelles*. Zinnias, Stars of India, and the Dahlia, of which the species, originally from Mexico, with simple single flowers, have yielded varieties with double flowers, until they have become the glory of our gardens in the autumn months, in conjunction with the Chrysanthemums.

MYRTALS.

Epigynous exogens, having still a strong tendency to the capitate condition which distinguishes the *Compositeæ*, they exhibit a polypetalous corolla with dichlamydeous flowers, axile placenta, and embryo with little or no albumen.

Trees and shrubs, sometimes climbers, with alternate or opposite simple leaves; flower regular, hermaphrodite; calyx four and five-lobed, adherent to the ovary; corolla four or five petals; stamens same number.	CCLXXIV. Combretaceæ.
Large trees, often spiny; alternate leaves; entire flowers, hermaphrodite; regular calyx, adherent, with six to ten teeth; corolla with petals corresponding to the teeth of the calyx; fruit a cluster; ovary one-celled; ovules pendulous; seed albuminous; cotyledons flat.	CCLXXV. Alangiaceæ.
Small heath-like bushes, with evergreen leaves, flat or acerose; flowers hermaphrodite, in racemes, corymbs, or heads; calyx adhering to the one-celled ovary; petals equal to the divisions of the ovary; stamens indefinite, often sterile; ovules erect from the base, solitary; capsule one-seeded.	CCLXXVI. Chamælaucieæ.
Herbaceous or shrubby plants, generally aquatic; leaves alternate, opposite, or whorled; flowers hermaphrodite, or unisexual by abortion; calyx open, minute, and four-lobed; corolla with three or four minute petals inserted in the summit of the calyx, one or both sometimes absent; ovary inferior, plurilocular; stamens definite; ovules pendulous.	CCLXXVII. Haloragaceæ.
Herbaceous plants or shrubs; leaves opposite or alternate; flowers apetalous or polypetalous, hermaphrodite, regular; calyx valvate, green, and sometimes prolonged into a tube; corolla with the petals inserted at the summit of the calyx; stamens definite; ovary four-celled, inferior.	CCLXXVIII. Onagraceæ.
Trees or shrubs of the tropics; leaves opposite, simple, entire, or toothed; flowers polypetalous, regular, hermaphrodite; calyx valvate, four to twelve-lobed; corolla with petals equal to the lobes of the calyx; stamens inserted with the petals; ovary inferior, two-celled; ovules pendulous.	CCLXXIX. Rhizophoraceæ.
Smooth-leaved bushes, with alternate leathery leaves narrowed at the base into a thick channelled petiole; flowers in threes, sessile in the axils of the leaves; calyx a thick leathery cap of five ovate segments, with valvate æstivation; stamens twenty, erect, also in the form of a cap; ovary buried at the base of corolla.	CCLXXX. Belvisiaceæ.
Trees, shrubs, and herbs, with leaves opposite or in whorls; flowers hermaphrodite; calyx five-lobed; corolla with petals equal to the lobes of the corolla; stamens definite, inserted with the petals; ovary plurilocular; ovules two, suspended from an axile placenta.	CCLXXXI. Melastomaceæ.
Trees or shrubs, with opposite entire leaves, sometimes alternate, generally furnished with glands secreting essential oils; flowers red, white, or yellow, hermaphrodite, regular; calyx four or five-lobed, adherent to the inferior one or many-celled ovary; corolla with petals equal to lobes of calyx; stamens indefinite; ovules many, two or many-celled, often one-seeded by abortion.	CCLXXXII. Myrtaceæ.

Large trees, with alternate, entire, or toothed leaves; large showy polypetalous flowers, racemose, terminal, or solitary; calyx superior, valvate or imbricate; corolla of six petals; stamens indefinite; ovary inferior, two to six-celled.	CCLXXXIII. Lecythidaceæ.

Mostly natives of the tropics, the group, from the associations connected with the Myrtles, whence it derives its name, has a certain European interest. The COMBRETACEÆ are mostly astringents, the bark of several useful in tanning; others yield gum; the galls of several species are useful dyes. In ALANGIACEÆ we have an order chiefly Indian, with aromatic roots; an eatable but insipid fruit, yielding valuable timber. The CHAMÆLAUCIEÆ, which Endlicher makes a sub-order of *Myrtaceæ*, are small, beautiful flowering bushes, resembling the Heaths; they abound in Australia; of their uses and properties little is known. The HALORAGACEÆ or Hipunds, are found in ditches, sluggish streams, mostly in temperate parts of the world. A few species occur in China, Australia, and the South Sea Islands.

The ONAGRACEÆ, or Evening Primroses, include the Fuchsias, Primroses, Clarkias, and some other garden favourites of great beauty, natives of the northern hemisphere, and abundant in the new world. Some of these, as the Jussieu's Fuchsias and Montonias, are used in the Brazils and Chili as dyes; others are astringents. Many of the genus *Œnothera* expand their flowers in the evening, whence their name of Evening Primrose. The RHIZOPHORACEÆ, or Mangroves, grow in muddy waters on the coast, where they soon form dense thickets on the edge of the seas and rivers of the tropics, which the sun's rays fail to penetrate; hence the putrid exhalations which render many tropical regions near the coast and large rivers so unhealthy. The BELVISIACEÆ, or Napoleonads of Endlicher, are smooth-leaved camelia-like bushes, wholly African and tropical, of whose uses little is known. The MELASTOMACEÆ are entirely exotics, and of both hemispheres, but mostly Asiatic; they are all slightly astringent. Many produce edible fruit, and some are useful in medicine. The MYRTACEÆ are natives of hot climates, within and without the tropics, *Myrtus communis*, with which we are mostly familiar, being a native of Persia. The order includes the *Eucalyptus*, so often spoken of in Australian travels, the Pomegranate (*Punica granatum*), and a number of other exotics equally well known

from their fruits or flowers. Lecythidaceæ Endlicher treats as a sub-order. It includes the *Leptospermeæ*, the Cajeput oil-tree, and other interesting genera.

Cactals.

In this group are ranged the well-known Cactuses, and other favourites of the greenhouse among the *Loasaceæ*. In appearance the group seems anomalous, but their dichlamydeous flowers and parietal placentæ bring them together in the opinion of botanists.

Trees and shrubs, with alternate simple leaves, deciduous leaflets at their base, flowers hermaphrodite, regular, arranged in spikes, racemes, or panicles, calyx tubular, adhering to the ovary, with ten to fifteen lobes, corolla five to ten petals, stamens equal to the lobes, ovary inferior.	CCLXXXIV. Homaliaceæ
Herbaceous plants, more or less covered with prickles, leaves opposite or alternate, flowers hermaphrodite, regular, calyx tubular, corolla with four or five concave petals, stamens indefinite, ovary inferior, one-celled, with several partitions	CCLXXXV. Loasaceæ
Trees and shrubs, with succulent spine, angular, depressed, or globular alternate leaves, deciduous stipules, but often wanting, and replaced by a cushion, flowers hermaphrodite, calyx many-lobed, corolla with numerous petals, stamens indefinite in number, ovary inferior, one celled, fruit fleshy, one celled, many-seeded, smooth, or covered with scales.	CCLXXXVI. Cactaceæ.

The *Homaliaceæ* are natives of tropical America, and between the tropics in Africa, the Isle of Bourbon, and Madagascar.

The *Loasaceæ* are American plants found over the whole continent; their most noted peculiarity being the secretion of an acrid juice with which the hairs on the stem are charged.

The Cactaceæ came originally from the American continent. They are at the same time fleshy and ligneous. Their branching stems present the most varied, often the most grotesque forms. Sometimes they are erect, like a tall fluted column; at others they are massed together like a solid sphere, tapering off into cylindrical branches, or flattened after the manner of the Indian Fig. In short, nothing is more varied than the aspect of the numberless Cactuses, which grow naturally in strange profusion in America, and which art has brought together in great quantities in our gardens for the purposes of study or gratification. The stem of the Cactus is generally destitute of leaves, the existence of which is, so to speak, only suggested by a small cushion situated under the bud. Nevertheless the genus *Pereskia* has true petiolate leaves, which are large and oblong, caducous, or deciduous. The buds, situated at the axiles of the leaves, are of two

kinds; the lower are furnished with spines, the upper are developed into branches and flowers. Fig. 441 represents *Mammillaria elephantidens,* one of this genus, cultivated in greenhouses.

The flowers of the Cactus are regular and hermaphrodite; their envelopes are composed of a great number of divisions, the exterior of which have a great analogy to sepals, whilst the internal ones

Fig. 441.—Mammillaria elephantidens.

resemble petals; it is not always possible to find the precise limit between the corolla and calyx. The stamens are very numerous, and have bilocular anthers; their valves facing the centre of the flower; the ovary inferior, and surmounted by a lengthened style, divided into several stigmatic branches. This ovary is unilocular, and has as many parietal placentæ on its interior as it has stigmatic branches. Upon each of these placentæ are found a number of anatropal ovules. The fruit is a pulpy berry. The seeds are nestled in the pulp, and have a straight or curved embryo, and little or no albumen.

If we examine more closely some members of this interesting

family—the *Opuntia*, for instance—we find the stem more or less flattened, with oval or oblong articulations, bearing bunches of needle-like hairs, and without any median nervure. The flowers in *Opuntia* are quite magnificent. Nothing is more curious than these large corollas clothed in the most vivid colours, which are so planted as to seem to be nailed upon the strong, prickly, and succulent rugged stem of the plants. The flowers seem to spring from the branches of hair, or from the edges of the articulations; they are white, red, or yellow, according to the species. Their stamens are endowed with great irritability. The fruit, of various size and colour, is eatable, and not unlike a large gooseberry in form and taste.

The Prickly Pear, or Indian Fig (*Opuntia vulgaris*), is a plant originally from the West Indies or America. The Opuntia bears a large comestible fruit. It has long been naturalised in the south of Europe, in Spain, Italy, Sicily, Greece, &c., where it is cultivated to make hedges and enclosures, its fruit being, to a considerable extent, the food of the inhabitants of these countries. *O. cochinillifera* is the plant on which the cochineal insect feeds and breeds. This is the little insect which produces the rich coloured pigment, employed in the manufacture of carmine.

The *Arens*, or Torch Thistle, has continuous angular stems, the angles charged with bunches of hairy prickles. The flowers are large and beautiful. Those of the Torch Thistle of Peru are solitary, about six inches in length, white within, greenish for the length of the tube, and rose colour upon the exterior limb.

It is to the genus *Cereus* that the gigantic species indigenous to Mexico and California belong. The stem of this vegetable wonder, flanked by its branches, resembles an immense candelabrum, fifteen yards high. In the engraving (Plate XXI.) we give a representation of the gigantic *Cereus* of Mexico, taken from an American work, entitled "Report of Explorations on the Mississippi," &c. The *Echino cactus*, originally from America, is frequently cultivated in this country. Its stems, clustered together in the shape of an egg or sphere, present longitudinal sides separated by straight furrows. These sides are furnished on their whole length with white, cotonous excrescences, provided with short and spreading spines. It is from the centre of these thorny tubercules that the flowers

Plate XXI.—Mexican Plants.

Aloe. Mecal Cactus. Melo Cactus. Cactus, or Ganos.

spring. They are always large and beautiful, and last for many days. The *Echino cactus* of Otto, which is frequently cultivated, is indigenous to Mexico. The *Melocactus* has a globular, ovoid, or pyramidal stem, with the sides separated by straight furrows. This stem is surmounted by a kind of woolly, or, rather, hairy tuft, formed of very compact spines, from the axilla of which the leaves spring; they are very small, and ephemeral in their duration. The *Melocactus vulgaris*, cultivated in gardens as an ornamental plant, was originally from the Antilles.

Lastly, we must mention the *Mamillaria*, of which we have previously given a representation. The thorny tubercles of this cactus are spirally disposed round the stem. The flowers, which last a long time, often surmount the trunk, forming a kind of crown to its branches.

GROSSALS.

If we except the fruits and the spines, there seems to be little in common between the Cactaceæ and Grossulaceæ; but that resemblance was considered so strong that the earlier botanists classed both in the same order. They now form distinct groups of orders.

Shrubs, sometimes armed with spines, leaves alternate, simple, lobed hermaphrodite flowers, often unisexual, calyx coloured, four or five lobed, with tube adherent to the ovary, corolla with small petals, equal in number to the lobe of the calyx, inserted at its orifice, stamens four, alternate with t petals	CCLXXXVII. Grossulaceæ.
Shrubs, with alternate toothed leaves, axillary flowers calyx superior, five-lobed, corolla of five petals, alternate with lobes of the calyx, stamens alternate wit the petals, rising from the calyx, fruit capsular	CCLXXXVIII Escalloniaceæ.
Shrubs with opposite leaves simple flowers, white or pink, calyx adherent, four and ten divisions, petals alternate with segments of the calyx, stamens double, or some multiple of the petals, ovary inferior; fruit capsular.	CCLXXXIX. Philadelphaceæ.
Trees and shrubs, with alternate, often serrated leaves; sepals four or five; petals same number, imbricated, stamens numerous, often in one bundle; ovary inferior, two or many-celled, fruit pulpy, one or many-celled	CCXC. Barringtoniaceæ.

The GROSSULACEÆ are chiefly natives of the temperate and colder regions of the northern hemisphere. The fruit, a berry, is mucilaginous—an agreeable mixture of malic, and nitric acid, and saccharine, with an astringent principle, which renders it pleasant and refreshing. The common Gooseberry (*Ribes grossularia*) is a shrubby plant, often armed with spines, placed under the leaves, which are alternate, or fasciculate, with palmated limb, having a

dilated petiole at the base. The flowers are arranged in bunches or clusters,—axillary in the species destitute of spines; solitary, or at least less numerous, in species thus armed. Calyx monosepalous, in five divisions. Corolla with five free petals, alternating with the sepals. Stamens, five and perigynous, are opposed to the sepals. Their filaments are free, their anthers bilocular, opening from either by two longitudinal slits. The pistil consists of an inferior ovary, surmounted by two short styles with obtuse stigmata. In the interior of the ovary, which is unilocular, are two placentæ, charged with numerous ovules placed horizontally and anatropical. The fruit is a berry (Fig. 442), crowned by the persistent limb of the calyx and the dried-up petals. The seeds are enclosed, and the integuments become gelatinous externally, internally crustaceous, contain an albumen, hard and nearly horny, and very abundant, at the base of which is found a very small, straight embryo.

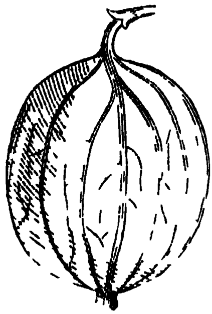


Fig 442 —The Gooseberry

Many species of Ribes are cultivated in gardens as ornamental plants, such as *R. aureum*, *R. sanguineum*, the deep red cluster of flowers thrown out by the latter being extremely beautiful. Others are cultivated for their fruit, such as the gooseberry, which we have described, the currants, red and white, both varieties of *R. rubrum*, and the black currant (*R. nigrum*), both of which throw out clusters of grateful berries, which are utilised by careful housewives, when ripe, being the fruit of which jellies and other preserves are made. The first,

Fig. 443 —Branch and flower of the White Currant.

R. grassularia, is spiny, especially in its natural state; its flowers solitary or gemmate; but varying much in garden varieties, both as to the size and colour of its fruit. The second is without spines; its fruit is borne in clusters (Fig. 442), red or white. In the third the fruit is in bunches of loose black berries, containing, as does its leaf, an aromatic resinous principle.

Cinchonals.

Epigynous Endogens, having the flowers dichlamydeous, in which they differ from Asarals; the corolla monopetalous, in which it differs from Cactals, Grossals, and Umbilifers; and a minute embryo, in which it differs from Campanals and Myrtals.

Small trees and shrubs, with numerous angular branches, leaves simple, entire, dentate, with short foot stalks, flowers hermaphrodite, regular, calyx adherent to the ovary, corolla epigynous, four, five, or six lobed, alternate with the same number of lobes of the calyx, stamens double the number of lobes of the corolla, ovary inferior, fruit a berry or drupe.	CCXCI. Vacciniaceæ.
Evergreen shrubs or trees, with opposite non-stipulate leaves, terminal yellow flowers, calyx superior, five-parted, corolla five, eight-parted, [illegible], stamens two inserted in the throat alternate with the segments of the corolla, anthers sinuous, bursting longitudinally, ovary inferior; fruit capsular, two-celled and many-seeded.	CCXCII. Columelliaceæ.
Trees or shrubs, with simple, opposite leaves, with leaflets quite entire, flowers generally hermaphrodite, rarely unisexual by abortion usually in panicles or corymbs, calyx tubular, adherent, corolla monopetalous inserted in the tube of the calyx, stamens four to six, alternating with the lobes of the corolla, ovary inferior, two or more celled, fruit a drupe or berry.	CCXCIII. Rubiaceæ.
Shrubs or herbaceous, sometimes climbing plants, with opposite, sometimes connate leaves, simple, rarely pinnate, without stipules, flowers in corymbs heads, or whorled, calyx five, rarely four lobed, adherent to the ovary, corolla monopetalous, stamens five, rarely four, inserted in the summit of the tube of the calyx, ovary inferior, three to five celled, fruit a berry.	CCXCIV. Caprifoliaceæ.
Herbaceous plants, with whorled leaves, without stipules, angular stem, flowers minute, calyx superior, four to six lobed, corolla monopetalous, stamens epipetalous, anthers straight, bursting longitudinally, fruit didymous.	CCXCV. Galiaceæ.

The Vacciniaceæ or Cranberries are found on mountainous and marshy places in temperate regions of the old and new world, chiefly in the northern hemisphere; a few, with parasitical habits, are natives of Brazil. The common Bilberry, or Blueberry of the Moors (*Vaccinium myrtillus*), is a well-known example. The Whortleberry (*V. uliginosum*), and the common Cranberry (*Oxycoccus palustris*), are equally well known in many parts of the British Isles.

The Columelliaceæ occupy an anomalous position among the surrounding orders. Professor Don thought their proper position near Jasmines, with which he found they corresponded in the structure and æstivation of the corella, in the bilocular ovary and erect

ovules. Endlicher, acting upon this supposition, has placed them among the Symplocaceæ. The only known species are from Mexico and Peru, and their uses still unknown.

The RUBIACEÆ, or CINCHONACEÆ, as Dr. Lindley names the order, are almost exclusively natives of the hottest parts of the world. Endlicher has divided this important Order into—

SUB-ORDER I. CINCHONEÆ, having numerous ovules in the cells; cells of the fruit many-seeded. This includes—

I. The tribe *Gardenideæ*. Trees or shrubs, with opposite interpetiolar stipules.

II. The *Eucinchoneæ*. Fruit a two-celled capsule; flowers sessile, collected into a head upon the receptacle.

III. The *Hedytideæ*, with a capsular two-celled fruit, opening at the cells.

IV. *Isertieæ*. Shrubs or trees; fruit drupaceous; two to six many-seeded bony nuts.

V. *Hamelieæ*. Fruit a many-celled berry and the cells many-seeded.

VI. *Cordiereæ*. Shrubs, with opposite leaves: broad interpetiolar stipules; fruit a many-celled berry; cells one-seeded.

VII. *Cerdiereæ*. Shrubs with opposite leaves; fruit a many-celled berry; cells one-seeded.

SUB-ORDER II. COFFEÆ, having ovules solitary, rarely two in the cells; cells of the fruit one or two seeded.

VIII. *Guettardeæ*. Shrubs or trees; fruit a drupe; seeds cylindrical.

IX. *Pæderieæ*. Climbing shrubs, with opposite leaves and interpetiolar stipules; fruit two-celled, unopening, hardly fleshy.

X. *Psychotrieæ*. Trees and shrubs, with opposite leaves; fruit a two-celled berry, containing two one-sided bony nuts or pyrenæ, flat on the inside, marks outside with a furrow, rarely one nut by abortion.

XI. *Spermacoceæ*. Fruit dry or slightly fleshy, usually consisting of two one-seeded carpels.

XII. *Anthospermeæ*. Herbs or under-shrubs, with flowers sometimes diœcious; corolla rotate; styles two; fruit a one-seeded carpel.

XIII. *Stellatæ*. Sometimes sub-shrubs, but usually herbs; leaves opposite, with two or three leaf-like stipules on the axil on each side; flowers hermaphrodite, rarely unisexual; corolla funnel-shaped; lobes valvate; styles two, distinct, but more or less united.

XIV. *Operculaceæ*. Herbs or shrubs, having opposite leaves; twin stipules on each side; fruit one-celled and one-seeded, joined together laterally into a head, an opening by two valves at the apex.

The greater part of this important family are found between the tropics, or in regions upon their borders, where they form a larger proportion of the vegetation as compared with any other order. The Stellatæ are confined to the hilly regions of Chili, Peru, and Australia, and the northern regions of both hemispheres—many of the madders or Stellatæ being British. Before noting the more remarkable species,—the produce of the tropics,—which are so essentially useful to man, we shall give, as a type of the order, a sketch of the floral structure of a species which is common in our own fields.

The Field Madder (*Sherardia arvensis*) is a small annual with flowers of a rose-shaded lilac, nearly sessile, and disposed in a dense head. The flowers are hermaphrodite and regular; the calyx presents six teeth, or lobes; the corolla is monopetalous, hollowed into a funnel shape, and four-lobed. There are four

stamens alternating with these lobes, inserted upon the tube of the corolla; anthers bilocular, opening from within by two longitudinal slits. The pistil consists of an inferior ovary, sur-

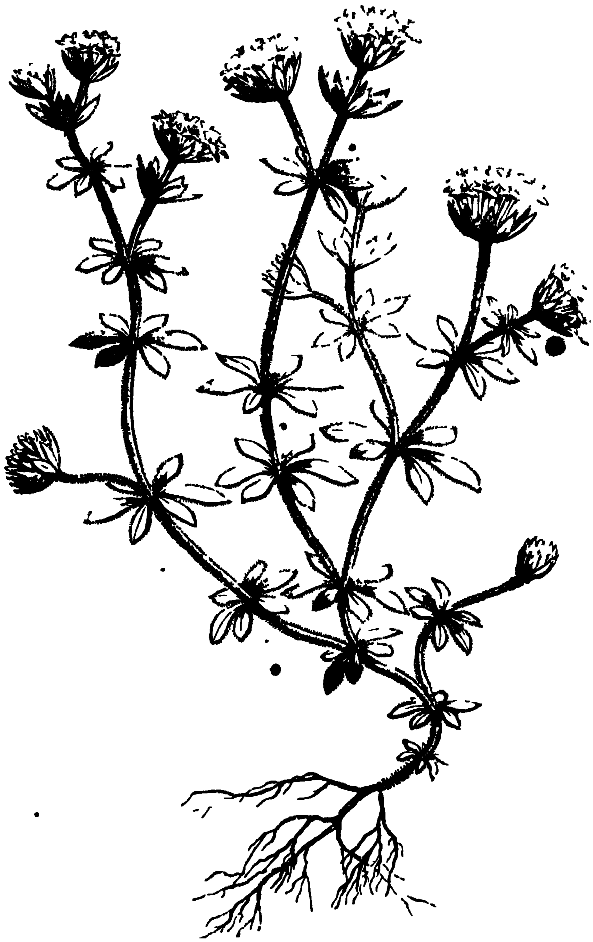


Fig. 443.—Sherardia Arvensis.

mounted by a style divided into two stigmatic branches. Each of the cells contains an ascending anatropal oval. The fruit forms two *achenes*, each covered by three lobes of the calyx. Under the

integuments of the seeds, an embryo, slightly curved, in a horny albumen. The leaves are simple, opposite, and accompanied by two lateral stipules, which resemble the leaves sufficiently to make it appear that there are six verticilate leaves without stipules. Besides the *Sherardia*, there are several other species, such as the Woodruff (*Asperula*), the Bedstraws, or Scratchweeds (*Galium*), the true Madder (*Rubia*), all common field plants. *Rubia tinctorum* is cultivated in the South of France, for the sake of its roots, which contain a colouring matter of a beautiful red, much used in dyeing.

Coffee-tree (*Coffea*) is an important section of the Rubiaceæ. They are evergreen shrubs, having lanceolate, wavy, and smooth leaves, resembling those of the Laurel. They are opposite, and accompanied by two lateral stipules; the flowers are white and odorous, forming an agglomerate of flowers in the axil of the leaves; the calyx is five-lobed; the corolla, funnel-shaped and also five-lobed; stamens five, with an inferior bilocular ovarium like the *Sherardia*. The fruit, a red berry, about the size of a cherry, consists of a thick and rather sweetish pulp, which encloses two nuts joined together, the walls of which are parchment-like. Each of these nuts encloses a seed, convex on the exterior, smooth and hollowed, and furrowed in the interior. The embryo is short, straight, and smooth, at the base of a hard albumen, which constitutes nearly the whole of the seed.

The Coffee-tree, which was brought originally from Abyssinia, was in the fifteenth century transported into Arabia, which has since become as a second home to this shrub, no coffee being equal to that produced in the neighbourhood of Mecca.

The *Cephælis* take rank next the Coffee-trees. They are small shrubs, natives of the solitary forests of Brazil. They are chiefly distinguished by the properties of their roots which yield ipecacuanha, a drug having bitter, acrid, and nauseous properties, but a valuable medicine; it is the produce of *Cephælis ipecacuanha* and some other species. The drug in which the emetic properties of this plant reside is found in the bark of the roots.

The Cinchonaceæ also belong to this group (Fig. 444). These are evergreen trees or shrubs which grow in the tropical Andes, between ten degrees of north latitude and nineteen degrees south, at a height of from seven to eight hundred feet above the level of

the sea. The Cinchoneæ have regular hemaphrodite flowers; monosepalous calyx with five teeth; the corolla is monopetalous, cup-shaped, and five-lobed; stamens five, alternate with these lobes, inserted upon the tube of the corolla; anthers two-celled, opening from within. The pistil consists of an inferior ovarium surmounted by a style, divided into two stigmatic branches. The ovarium has two cells, in each of which is a large placenta filled with anatropal ovules; the first is a capsule which opens from above in two valves; the seeds are winged. Wonderful medicinal properties reside in this family. The bark of most of the ligneous species contains an astringent and bitter principle, which, though existing in other genera, is more abundant in the Cinchona, and especially in *C. calisayra*, the bark of which appears to be the richest in quinine of all the known species.


Fig. 444.—Flower of Cinchona.

The mode of procuring this invaluable febrifuge is interesting, and has been recorded in the following notes. "About the end of June, 1847," says Mr. Weddell, "I set out to walk to the province of Casabaya. This province is divided by the Cordilleras into two distinct regions; the one forming table-lands, the other comprehending a long series of parallel valleys. . . . . These valleys furnish the greater part of the Peruvian bark. It would be difficult to give an idea of all the treasures of vegetation buried in these vast solitudes. The thirst for gold formerly peopled them, but the wilderness has resumed its empire, and the axe of the cascarillero alone breaks its silence now.

"The name of cascarillero is given to those men who cut the Peruvian bark in the woods; they are brought up to this occupation from their childhood, and instinctively, as one might say, they find their way to the centre of the forest, through almost inextricable labyrinths, as if the horizon were open before them.

"These cascarilleros do not gather the Peruvian bark for their own profit; generally they are enrolled in the service of some tradesman or small company, who send a sort of overseer to superintend their labour. Having fixed upon a portion of the

forest favourable to their purpose, the party proceed to make roads to the point which is to be the centre of their operations. From this time, every part of the forest—a view of which is commanded by the new pathway—becomes provisionally the property of the party, and no other cascarilleros dare work it.

"The overseer, having established his camp, proceeds to build a hangar, or wooden hut, in which he can shelter himself and store his provisions; and if their stay is likely to be prolonged, he does not hesitate to sow maize and vegetables for the use of the party; the cascarilleros, in the meantime, wandering over the forest one by one, or in small bands, each enveloped in his poncho, with provisions for several days, and the blankets which constitute their beds. They range the forest, axe or knife in hand, to clear away the innumerable obstacles which arrest their progress at every step; for the cascarillero is exposed to dangers which often endanger his life. The forests are rarely composed entirely of Cinchonia; but these shrubs form groups more or less numerous, scattered here and there in the depths of the forest; sometimes—and this is commonly the case—they are completely isolated. If the position be favourable, a glance at the branches: a slight display of colour, peculiar to the leaves—a particular colouring of these same organs—the aspect produced by a large mass of inflorescence reveals the branch of the *manchas*, as the Peruvians term the tree, at a great distance. In other circumstances, he must content himself with an inspection of the trunk, in which the outer layer of bark—the fallen leaves, even—are sufficient to make known the neighbourhood of the object of their search. Having marked the group, they begin operations by felling the tree with the axe, a little above the root, taking care, in order to lose none of the bark, to bare it at the place where the axe is to be laid; and as the thickest part is surrounded by the largest quantity of bark, and is consequently the most profitable, it is usual to dig out the earth at the foot of the trunk, so that the barking should be complete.

"The Cinchona is sometimes completely surrounded, as in a pit, with *lianes*, which shoot from tree to tree.

"I remember having cut down a large tree, hoping to get the flowers, but after having knocked down three neighbouring trees, it still remained standing, supported in that position by the *lianes*,

Plate XVI.—Gathering Bark in a Peruvian Forest.

which were wound round its branches, supporting it as if wrapped in a shroud. When, at last, the tree falls, the outer bark is gathered by means of a wooden mallet, or the back of an axe. The part thus stripped is then brushed, and divided throughout by uniform incisions. The bark is separated from the trunk by means of a knife, with the point of which the surface of the wood is raised. The bark of the branches is separated much as that of the trunk. The details of dressing the bark vary a little in the two cases; in fact, the thinner plates of the bark of the branches, which make the rolled quinine, called *canuto,* are merely exposed to the sun, when they take of themselves the desired form, which is that of a hollow cylinder; but those which are the produce of the trunk, and constitute the ordinary bark, which is called *tabla,* are subjected during the drying process to great pressure, without which they would take the shape of the others. After their first exposure to the sun, the squares are disposed one on the top of the other, just like the planks of deal in a timber-yard, and are kept level by means of heavy weights laid on the pile. The next day the squares of bark are put back again in the sun for a short while, then back again into the press, and so on. In this state they are left at last.

"But the work of the cascarillero is not nearly finished, even when the preparation of the bark is over; his spoil has to be conveyed to the camp. With a heavy load upon his shoulder, he has to retrace the intricate paths that he traversed with difficulty without his burden. I have seen more than one district where the bark had to be carried through the wood during fifteen or twenty days—it is difficult to conceive how such labour can be properly remunerated.

"The care of packing the bark, which devolves upon the overseer, is no unimportant part of the labour. He arranges the different loads, as the cutters bring them into the camp, in parcels, which are sewn up in woollen canvas packing."

In this condition the bales are transported on the backs of men, asses, or mules, to the town depôts, where they are packed in copper, in which state they acquire a great solidity. When dry they are called *surous,* and in this condition they reach Europe. Plate XVI., copied from Mr. Weddell's work, represents

the harvesting of the bark of the Cinchona in the manner described in a Peruvian forest.

We cannot conclude our remarks on the Rubiaceæ without mentioning a few of the more ornamental species which embellish our hothouses. Such are the *Ixora coccinea;* beautiful shrubs of the island of Ceylon, with persistent leaves, slightly succulent, and a bright red flower, disposed in tufts, which long preserve their brilliancy. The *Ixora odorata* is another species, a native of Madagascar, whose large red and white corolla exhales a delicious odour. The *Rondeletia speciosa,* from the Havanna, has tubular flowers, of a brilliant scarlet outside, with yellowish orange inside the throat. The *Rogiera,* from Guatemala; the *Bouvardia,* from Mexico; the *Luculia gratissima,* from Nepal, whose rose-coloured corollas exhale a delicious perfume; and the *Gardenia florida,* commonly called the Cape Jasmine, are all beautiful members of the interesting order Rubiaceæ.

The Caprifoliaceæ are natives of the northern parts of Europe, Asia, and America, but rare in Northern Africa, and still less known in the southern hemisphere. Many of the family are climbing plants, of which section the Honeysuckle is an example. The British species are sometimes divided into—

1. *Sambucineæ,* with rotate corolla and five-celled fruit, including the Guelder Rose (*Viburnum*) and the Elder (*Sambucus*); and

2. *Caprifolieæ.* Corolla tubular and campanulate, with a two-lipped or five-cleft limb, including the Honeysuckle (*Lonicera*) and *Linnæa.* Among the fine exotics belonging to the order are the Loniceras and Viburnums of China and Japan, and *Leycesteria formosa,* named by Wallich in honour of Judge Leycester, an elegant and beautiful flowering shrub, the deep green hue of its stem and leaves contrasting finely with the purple of its large bracts and berries.

The Sambuceæ, or Elders, are familiar inhabitants of our hedgerows, and about cottages and farmhouses, generally near ponds or ditches with stagnant water. The dwarf species (*S. ebulus*) is fœtid, and somewhat nauseous. The common Elder (*S. nigra*), a small bushy tree, is an elegant shrub, with delicate cream-coloured flowers in cymes, which are in full blossom in June, and its dark purple clusters of berries are equally beautiful in Sep-

tember and October. Large orchards of Elders are cultivated in Kent for the purpose of making wine from their fruit. The flowers are also distilled with water and alcohol, and yield a perfumed liquid known as *elder-flower water*, much approved for the toilet, and in confectionary.

The Guelder Rose and the Laburnum have a fine effect in a well-arranged shrubbery, the balls of white blossom of the first contrasting beautifully with the rich yellow clusters of the latter.

The Honeysuckle (*Lonicera periclymenum*) is also the Woodbine of the poets, the "twisted Eglantine" of Milton and of Shakespeare, who combines them in one stanza—

> "So doth the woodbine, the sweet honeysuckle,
> Gently entwist the maple."

In many green lanes in Britain this sweet-scented climber may be observed encircling the stem of some young tree, which bears indelible marks of its friendly embrace as it winds round the stem from left to right. The bright red, or rather crimson, berries of the Honeysuckle succeed the fragrant verticiles of flowers, equalling them in beauty.

Linnæa is a lowly plant, the name of which was changed from *Nummularia*, at the request of the great Botanist, to commemorate his own name. "Its lonely, depressed growth," he said, "was a fitting emblem of his own early fate." It is found in Fir woods in the North of England and Scotland, and also in the northern regions of Europe, distinguished by its slender, trailing stem, and drooping flowers of pale purplish rose colour, and something between a bell and funnel shaped corolla.

UMBELLIFERS.

The polypetalous corolla, dichlamydeous flowers, inferior fruit, and large solitary seed, and small embryo lying in a large quantity of albumen, are the distinctive characters of the Umbelliferous exogens.

Herbaceous, rarely shrubby plants, with solid and cylindrical, sometimes fistular and furrowed stem, alternate leaves, rarely opposite or entire, sometimes simple, sheathing at the base, flowers in umbels, generally surrounded by an involucre; calyx, five-toothed, adhering to the ovary; corolla with five petals, stamens five, inserted alternately with the petals in the top of the calyx; fruit, two carpels, separating into two parts near the base. — CCXCVI. Umbelliferæ.

Trees and shrubs, rarely herbaceous, sometimes climbing plants; leaves alternate, without stipules, but with foot-stalks widening at the base and sheathing; flowers hermaphrodite; calyx adherent; corolla with five or ten petals, valvate in æstivation; stamens equal in number, sometimes double, and inserted with them on the ovary; fruit a berry.	CCXCVII. Araliaceæ.
Trees or shrubs, rarely herbaceous; leaves opposite, rarely simple or alternate; flowers hermaphrodite, occasionally unisexual by abortion; capitate, umbellate, or in corymbs; calyx adherent; corolla with four petals; stamens equal in number and alternate with them, inserted in the orifice of the calyx; fruit a drupe.	CCXCVIII. Cornaceæ.
Shrubs or small trees, with alternate toothed leaves and stipules, both deciduous; flowers small, hermaphrodite, unisexual by abortion; calyx adherent to the ovary; corolla four-petalled, inserted in and alternating with the lobes of the calyx; stamens eight, four of which, alternating with the petals, are fertile; four opposite to them without anthers.	CCXCIX. Hamamelidaceæ.
Branching heath-like shrubs, with small, alternate entire leaves, without stipules; flowers small, hermaphrodite, capitate, panicled, or terminal; calyx adherent to the ovary, nearly free; corolla with five imbricate petals; stamens five, alternate with the petals, inserted in the throat of the ovary.	CCC. Brunoniaceæ.

This important group of exogens, which is familiarly represented by the Hemlocks, Wild Celery, Parsleys, and Fennels, rises into importance when we come to consider the singular forms which the order assumes in the *Astrantia*, *Eryngium*, and *Leucolæna*, where, instead of the hollow, fistular, and reeded stem of the Hemlock, they become solid, branching bushes, with panicled flowers, and the inconspicuous involucre of *Œnanthe* becomes great white three-lobed plates surrounding the flower in *Leucolæna rotundifolia.*

The arrangement of the Umbelliferæ has received great attention from botanists, and De Candolle has published a Memoir which is generally received as a satisfactory solution; the development of the ribs of the fruit, the presence or absence of reservoirs of oil, called *Vittæ*, and the form of the albumen being the leading features of his arrangement. "It must be obvious, however, to every botanist," says Dr. Lindley, "that the genera and tribes are alike unsatisfactory, and that the arrangement of Umbellifers upon sound principles still remains to be achieved."

The following is a brief view of the arrangement proposed by De Candolle:—

SUB-ORDER I. ORTHASPERMÆ.

Albumen flattish in the interior; umbels simple; fruit without vittæ.

TRIBE I. HYDROCOTYLEÆ. Fruit contracted; carpels convex, with five primary ribs; petals entire; including the *Eryngias*, *Leucolænas*, *Bowlesias*, and *Azorella*, of warmer climates, with the White Rot or Pennywort (*Hydrocotyle vulgaris*) of our own marshes.

TRIBE II. MULINEÆ. Carpels contracted at the base, flat at the back, without vittæ; including *Bolaxozebaria*, whose tufts of close entangled shoots are described by Dr. Urville as resembling haystacks, which the most experienced eye might doubt, so much are they at variance with the ordinary structure of umbels. The Mulineæ chiefly belong to the southern hemisphere, having no British representative.

TRIBE III. SANICULEÆ. Ovate globulous fruit; carpels with five primary ribs, without vittæ; secondary ribs covered with scales; petals erect and notched in the margins; including *Horsfeldia*, where panicles and racemes of flowers are substituted for umbels. The Wood-sanicle (*Sanicula Europea*), the Eringos (*Eryngium*), the Starworts (*Astrantia*), are the British representatives of this tribe.

TRIBE IV. AMMINEÆ. Fruit didymous: carpels with five thread-like ribs, which become winged seeds, cylindrical or convex on one side, flat on the other; including the Carrots, Parsnips, and Skirrets (*Sium*), the Earth nut (*Bunium*), the Anise, or Burnet Saxifrages (*Pimpinella*).

TRIBE V. SESELINEÆ. Fruit nearly cylindrical; carpels dorsally compressed, with five thread-like or winged ribs; including *Anes*, or *Horza capensis*, and *Fœniculum capensis*, both acceptable esculents at the Cape of Good Hope, and *Meum*, whose sweet aromatic roots form an ingredient in Venetian treacle; Samphire (*Crithmum Maritimum*), the Dropworts (*Œnanthe*), and *Lichtensteinia pyrethrifolia*, from the roots of which the Hottentots prepare an intoxicating beverage.

TRIBE VI. ANGELICEÆ. Fruit compressed dorsally; carpels five-ribbed; three dorsal ribs, thread-like or winged, two others lateral and expanded into broader wings. This group includes Angelica root (*Archangelica officinalis*), fragrant and sweet when first tasted, but pungent and bitter, leaving a glowing heat in the mouth, after a time.

TRIBE VII. PEUCEDANEÆ. Fruit, compressed dorsally; carpels with five thread-like limbs; fruit with one wing on each side, flattened; including the Hog's Fennels (*Peucedanum*), the typical genus.

TRIBE VIII. TORDYLIUM, or Hartworts, have the compressed fruit girded by dilated margin; ribs scarcely visible.

TRIBE IX. SILERIDEÆ. Carpels with five primary ribs, the side one emarginate, the secondary one less prominent.

TRIBE X. CUMINÆ. The fruit contracted laterally; carpels with five thread-like primary ribs, the lateral ones marginating with four secondary, all wingless. These three sections include only a few genera, which are only known in Britain as cultivated plants, and scarcely that. Cummin (*Cuminum cyminum*), formerly used in medicine, is now confined to veterinary practice.

TRIBE XI. THAPSIDÆ. Fruit compressed dorsally; carpels with five thread-like primary ribs, sometimes bristly, lateral ribs on the commissure, four secondaries, thread-like, the outer are all winged. Of the *Thapsiæ* there is no British species; *Thapsia Sylphium*, a native of North America, was also known to the ancients as yielding the juice called Silphium, in the neighbourhood of Cyrene. *Laserpitium glabrum* is acrid, aromatic, and stimulating.

TRIBE XII. DAUCIDEÆ. Fruit compressed dorsally; carpels with five bristly thread-like primary ribs, the lateral ones on the flat face; four secondaries prominent, and prickly; seeds flattish, inclined to cylindrical: includes the Carrot (*Daucus carota*), which is common enough by the way-side in its wild state, where its umbels form a hollow cup like a bird's nest, by which name it is sometimes called.

SUB-ORDER II. CAMPYLOSPERMÆ.

Albumen involute, sometimes channelled on the inner side.

TRIBE XIII. ELÆOSINEÆ. Fruit cylindrical, compressed from the back; carpels furnished with primary and secondary ribs; the two dorsals, secondaries, nerve-formed; the two laterals expanded into wings, with the margins waved.

TRIBE XIV. CAUCALIDÆ. Fruit contracted from the side; carpels with five thread-like prickl primary ribs, and four secondary ones, the latter prominent and prickly; seeds involute; includes the Bur parsleys (*Caucalis*), and the Hedge Parsleys (*Torilis*).

TRIBE XV. SCANDICEÆ. Fruit compressed laterally, usually beaked; carpels with primary ribs only; winged lateral ribs, marginating all equal, obliterated at the base, but conspicuous at the apex; seeds cylindrically convex, with a deep furrow in front, involute on the margin; includes *Anthriscus*, or Beaked Parsleys, Hares' Parsley, and Chervils (*Chærophyllum*), Sweet Cicely (*Myrrhis*), and Shepherds' Needle (*Scandix*).

TRIBE XVI. SMYRNEÆ. Fruit inflated, compressed laterally; carpels with five primary ribs only, later ones marginate; seeds involute, or furrowed internally, crescent shaped or complicate; includes some of the most poisonous plants in the whole range of the vegetable world, the most virulent, perhaps, being the common Hemlock (*Conium Maculatum*), Cowbane, or Water Hemlock (*Cicuta virosa*), is not less deadly. Some of the genera, however, are harmless; *Aracacha esculenta*, an inhabitant of the tableland of Grenada, has large esculent roots like the Parsnip, but superior to it; and *Prangos pabularia*, a herbaceous plant of the arid plains of southern Tartary, is a favourite with the herds of sheep which graze on the plains.

SUB-ORDER III. CÆLOSPERMÆ.

Albumen involutely curved from the base to the apex.

TRIBE XVII. CORIANDREÆ. Fruit globose, or of two globose carpels, furnished with five primary depressed and flexuose ribs, all wingless. This group includes the Corianders (*Coriandrum sativum*), in which the resinous and aromatic principle, which gives the plant a somewhat fœtid odour when merely bruised, gives the fruit a fragrant and aromatic odour when dried.

The UMBELLIFERÆ thus include an immense variety of vegetable forms, some of them yielding valuable contributions to the

table, others deadly poisons when improperly used, but all of them offering interesting objects for botanical study. We shall take a cursory glance at the more interesting species, taking them at random as they present themselves. The genus *Angelica*, with which we commence our remarks, is so named from *angelus*, an angel, having reference to the supposed angelic properties of the

Fig 445.—Angelica.

several species. The *Angeliceæ* are plants with pinnately decompound leaves, compound umbels of white, pale, pink flowers, the fruit surrounded by a double ring. The Garden Angelica (*Archangelica officinalis*), formerly largely cultivated on account of aromatic pungent leaf stalks (Fig. 445), is a pretty herbaceous plant, indigenous in the mountains of the south and east of France, and probably in England; it is tap-rooted, the root rather volumi-

nous. Its bluish green stem attains the height of three feet and upwards. This stem is tumid or hollow, as are the petioles of the leaves, which are large, doubly compound, and serrated. The flowers form little umbellicles, disposed again in umbels; they are small, and of a greenish colour. The calyx presents a limb formed of five very small teeth. The corolla is composed of five petals, free, elliptic, entire, curved; from within it has five stamens, dorsally attached to the filaments, and alternating with the projecting petals, opening from within by two longitudinal clefts. The pistil is composed of an inferior ovary, surmounted by two spreading styles, terminated by a small ovoid stigma. This ovary is two-celled, each cell enclosing a suspended anatropal ovule. When at maturity, the fruit, which is winged, constitutes two achenæ, one for each cell, all of which finally separate, and remain suspended at the extremity of the two filaments, which are prolongations of the receptacle. Each achena encloses one seed, formed almost entirely of horny albumen, towards the upper extremity of which a small cylindrical embryo is enclosed.

The family of the Umbelliferæ is one of the most important of the vegetable world, as well for the number of the species which compose it, as for the medicinal and economic properties which belong to the different species. One of the characteristic traits in the organisation of the Umbelliferæ consists in the presence of reservoirs or canals within the fruit, which contain aromatic volatile oils.

The Angelica (*Archangelica officinalis*), which we have just been examining, contains an aromatic and stimulating juice in abundance; it is principally cultivated for the confectioners, who prepare a preserve from the young stems, which are candied with sugar and perfumed, to neutralise the bitterness and acridity of the plant. The Wood Archangel (*A. sylvestris*), which grows wild on banks of rivers, and in wet and marshy places, contains analogous properties, but in a less degree. The same is the case with the Imperial Angelica and the Master Wort.

A greater number of the Umbelliferæ, which are cultivated in all parts of Europe, furnish fruits with a hot and aromatic flavour, which have been employed from time immemorial as condiments. Such are the Aniseed (*Pimpenella anisum*), Cummin (*Cuminum*

Cyminum), Dill (*Anethum graveolens*), Coriander (*coriandrum sativum*), Caraway (*Carum carvi*), Fennel (*Fæniculum vulgare*), &c. Several of the Umbelliferæ occupy important places in our kitchen gardens. The root of the Wild Carrot (*Daucus carota*), so common in our fields, is small, heavy, fibrous, and of an acrid flavour. In its wild state this root cannot be eaten, but under the influence of culture it becomes fleshy, voluminous, fæculent, and sweet, while retaining its aromatic flavour.

The Parsnip (*Pastinacea sativa*) grows spontaneously in the fields of all parts of Europe. Like the Carrot it is tap-rooted, and culture has rendered it alimentary, but the flesh is doughy, and slightly bitter.

Smallage (*Apium graveolens*), when cultivated, takes the name of Celery. Its roots in the wild state are acrid and strongly odorous, but under the influence of culture they acquire a sweeter flavour. When its long petioles have been softened, and had the colour taken from them by blanching, that is, by the plant remaining in the dark, they are considered one of the luxuries of the table.

Parsley (*Petroselinum sativum*), indigenous to the South of Europe, is now cultivated chiefly for the sake of its leaves; the same is the case with the Chervil (*Sandise cerefolium*).

Some of the Umbelliferæ have poisonous or narcotic properties. The first in this list is the Hemlock (*Conium maculatum*). It is a common plant on the road-side, on rubbish heaps, in burial-grounds, and in damp shaded places in the neighbourhood of habitations. Its root is white and spindle-shaped. Its straight branching herbaceous stem is from a yard to six feet high; it is smooth, that is to say, without hairs, cylindrical, glaucous, slightly fluted, and is spotted with marks of a deep purple colour. It has very large, alternate, deeply-cut, compound leaves, with profoundly dentate, lengthened folioles; its flowers are small, white, and disposed in terminal umbels, consisting of from ten to twelve rays. Its petals are almost equal, sessile, and somewhat heart-shaped. Upon each of the two lateral portions of the fruit are five projecting crenulated ribs, which give it the appearance of being all covered with small asperities, or rotund tubercles. Any part of the Hemlock, when crushed between the fingers, exhales a fœtid and disagreeable

odour. It is well known that this plant constitutes a violent poison to man, and still more so to animals. The proper antidote to poisoning by Hemlock is to provoke vomiting, followed by administering tonic drinks. The poisonous properties of Hemlock have been known from the most ancient times; Socrates and Phocion were recompensed for the services they had rendered to the Greeks by having the choice of drinking the juice of this plant, or the dagger.

The Water Hemlock, or Cowbane (*Cicuta virosa*), is a still more active and violent poison than the Common Hemlock. It is happily very rare; it grows on the banks of ponds and ditches, and in turfy marshes.

Lastly, we must mention the *Æthusa cynapium*, or Little Hemlock, which is commonly found in cultivated places. In kitchen gardens this plant may easily be mistaken for Parsley, which it very much resembles when young and imperfectly developed. It may be distinguished from this potherb by the following characteristics:—The leaves of the Parsley are divided twice; its folioles broad and divided into three sub-cuniform and dentated lobes; those of the Little Hemlock are divided three times, its folioles are more numerous, straighter, sharp-pointed, deeply-cut, and dentated. Besides, the odour of the Parsley is agreeable, refreshing, and aromatic; whilst that of the Little Hemlock, like the others, is nauseous and fœtid. If the two plants are in flower they will be distinguished at the first glance, for the flowers of the Parsley are yellowish, whilst those of the Hemlock are white. The stem of these plants also present different characteristics: that of the Little Hemlock is almost smooth, the lower part reddish, and the whole slightly tinged with red; the stem of our aromatic vegetable on the contrary is channelled, and green.

The Araliaceæ are trees and shrubs of the tropics, and of their borders in both hemispheres, especially in the Western, where they are plentiful. *Adoxa maschatellina*, and the Ivy (*Hedera helix*), are the only plants of the order indigenous to the British Islands; the former is distinguished by its slightly musky odour, and its greenish-yellow flowers, which grow in woods and shady places. The Ivy is universally diffused, its habitat woods, hedges, on old

buildings and rocks, or trunks of trees, on which its coriaceous evergreen leaves and clinging and trailing branches form a prominent object. Some strange confusion has arisen, as we learn from the new edition of Sowerby's Botany, between the Ivy and the Yew, in the writings of the poets, which Dr. Prior explains thus: "The Chanecopetys of Pliny, as we learn from Parkinson, was called in English, Ground Pine and Ground Ivie, after the Latin word *Iva*. But the name Ground Ivy had been assigned to another plant which was called in Latin, *Hedera terrestris*, and thus Ivy and Hedera came to be regarded as equivalent terms. But there was again another plant which was also called *Hedera terrestris*, viz., the creeping form of the Ivy (*Hedera helix*), and as Ivy had become equivalent to Hedera in the former case, so it did in this too, and eventually was appropriated to the full-grown evergreen shrub so well known. The botanical names of the Yew are so completely confused by the older botanists with those of the Ivy, that, dissimilar as are the trees, there can be no doubt that the origin of their names is identical."

The root of *Panax quinquefolium*, a species belonging to this order, furnishes a drug much used by the Chinese under the name of Gingseng; and *P. fruticosus*, and *P. cochleatus*, natives of the Moluccas, are used as aromatic medicines by native practitioners in the East.

The CORNACEÆ are found all over the temperate parts of Europe and America. Some of them, as *Cornacea floritta, sericea*, and *cirrinata*, are said to possess tonic properties of a high order. The Cornel, or Dogwood, is a tree sometimes seen in our hedges, and cultivated in our plantations; and the Cornelian Cherry (*Cornus mascula*) is common on the Continent, where its little clusters of starry yellow flowers are the earliest harbingers of spring.

The HAMAMELIDACEÆ, or Welsh Hazels, are found in North America, Japan, China, Central Asia, and South Africa; its most attractive member, the genus *Rhodiola*, "whose great red involucral leaves," says Dr. Lindley, "give quite a new aspect to the order, and points at an affinity of some kind with Liquidambars." The BRUNONIACEÆ are, with the exception of one species found at the Cape of Good Hope, all natives of Australia,

where they are found in great abundance; but species of *Scævola* are also found in the Moluccas. *Brunonia Australis* is an interesting fragrant Australian perennial.

ASARALS.

Epigynous exogens, with monochlamydeous flowers, and small embryo lying in a large quantity of albumen, which Dr. Lindley places at the end of his system, but acknowledges the position to be anomalous as respects their woody structure, the peculiarity of their trimerous flowers, and inferior ovary, abounding in ovules, which have no parallel near where they are placed. Endlicher, on the other hand, places them with his TERMINALIACEÆ and NEPENTHACEÆ.

Trees, shrubs, or herbaceous plants; leaves alternate, rarely opposite, sometimes scale-like and non-stipulate; flowers hermaphrodite, rarely unisexual by abortion, arranged in spikes or racemes; perianth adherent to the ovary; stamens four or five, opposite the segments of the perianth; anthers opening longitudinally; fruit one-seeded, nut-like, and slightly fleshy.	CCCI. Santalaceæ.
Trees, shrubs, under-shrubs, or herbaceous plants, with opposite entire leaves, veinless, fleshy, non-stipulate; flowers hermaphrodite; calyx tubular, adherent to the ovary, with free entire margin; petals four to eight, linear frequently of great length and brilliancy; stamens equal in number; ovary inferior; anthers turned inwards.	CCCII. Loranthaceæ.
Shrubs, for the most part parasitical, with simple opposite leaves with stipules veinless, thick, and leathery; flowers unisexual, in spikes or panicles; perianth adherent with the ovary, having three to five fleshy triangular divisions, valvate in æstivation; stamens equal to the divisions of the perianth; ovary inferior; fruit fleshy, one-celled.	CCCIII. Viscaceæ.
Herbaceous plants or shrubs, the latter often climbing; leaves alternate, simple, and stalked, often with a leafy stipule opposite the leaf; flowers hermaphrodite; calyx adherent, tubular; stamens six to twelve, arising from the base of the perianth; ovary inferior, six, rarely three or four-celled; ovules inverted; fruit a capsule or berry, dry, with three, four, or six many-seeded cells.	CCCIV. Aristolochiaceæ.

The SANTALACEÆ, or Sandal-weeds, are found in Europe and North America as humble weeds, but in Australia, the East Indies, and the South Sea Islands, they expand into large shrubs or small trees, as *Santalum album*. This tree is chiefly valuable for its wood, which is hard, heavy, admits of a high polish, and yields a fine perfume; qualities which recommend it for all kinds of fancy furniture and boxes. It is also burnt in temples, as incense, its fragrant odour being due to an essential oil said to be heavier than water.

The LORANTHACEÆ are natives of the tropics, both of Asia and America, but rare in Africa, where, however, the parasitical genera are found hanging in clusters from the trees on which they grow. Their economy presents some very curious phenomena. In *Viscum*,

the Mistletoe, according to Decaisne, the ovule does not appear till three months after the pollen has taken effect. Griffiths, who has also minutely studied *Loranthus*, states that the ripe seeds adhere firmly to the substance on which they are applied, by means of their viscid coating, which hardens into a transparent glue, and in two or three days after application the radicle curves towards its support, becoming enlarged and flattened as soon as it reaches it. By degrees a union is formed between the woody system of the parasite and stock, the fibres of the sucker-like root of the former expanding on the wood of the latter in the form of a bird's foot. Up to this time the parasite has been nourished by its own albumen, but as soon as it has acquired the height of one or two inches a lateral shoot is sent out, which adheres to the stock by means of sucker-like productions, which frequently run to a considerable distance, covering the tree with parasites.

Mr. Myers, who has carefully studied the order, draws a distinction between *Loranthus* and *Viscum*. The former distinguished by its large, showy, dichlamydeous, crimson flowers, with lengthened stamens, and an ovary containing a solitary ovule, suspended from the summit of a cell, with a large fleshy cotyledon. Viscum, on the contrary, having small, pale, diœcious, monochlamydeous flowers, with stamens sessile, or nearly so, different in structure, with dissimilar pollen; a unilocular, turbinate ovarium, with three ovules attached to a free central placenta. On these grounds he founds the new order VISCACEÆ, or Mistletoe.

The Mistletoe is supposed to be propagated by birds, especially by the Fieldfare and Misselthrush, which feed on the berries. The mode in which the propagation of *Myzodendron* is effected is also clearly demonstrated by Dr. Hooker. Here the fruit is provided with long, feathery processes, analogous to the pappus of the Compositeæ, which floats them in the air, and afterwards assists to hold them on to the branches while the radicle insinuates itself into the plant. The genera of the order are very limited: *Viscum* and *Arceuthobium*, which are confined to Europe; *Myzodendron* and *Lepidoceras* to the southern parts of Chili; *Eubrachion* to the banks of the Uruguay; and *Phoradendron*, numerous in species, which is disseminated over the tropical regions of the Old and New World.

The Aristolochiaceæ are common in tropical America, sparingly in North America, Europe, and Siberia, and in small numbers in India. Two species are said to be British plants, but the rarest of our reputed species, and probably an accidental importation. *Aristolochia blematitis* is recorded as being found growing on old walls, &c., near Spittal, in Lincolnshire.

The distinguishing characteristic of the order resides in the flowers, which have no corolla, and are constantly divided into three segments. The stamens have the same ternary characters, and the cells of the fruit are three or six, always adherent to the calyx. The arrangement of the wood is also peculiar, their stems being composed of longitudinal plates, surrounded by a central pith, with an exterior bark; but these plates are not placed in concentric circles, as in other exogenous plants, but continue to grow, uniformly and uninterruptedly, as long as the plant lives. The most remarkable species are found in tropical America, where the gigantic size and grotesque appearance of their flowers excite the wonder of the traveller; of these, *A. cymbifera*, the border of whose calyx resembles one of the lappels of a Norman woman's cap, measures seven or eight inches in length; while the flowers of *A. cordiflora* and *A. gigantea* are from fifteen to sixteen inches across. They are generally tonic and stimulating, and several of them are used in medicine.

PART III.

GEOGRAPHICAL DISTRIBUTION OF PLANTS.

LINNÆUS, whose singular genius foresaw most of the conquests reserved for his favourite science—the study of botany—laid the foundations of Botanical Geography. In the prolegomenia of his "Flora Laponia," the immortal Botanist of Upsal says, in the poetical and concise style which is peculiar to him: "The dynasty of the Palms reigns in the warm regions of the globe; the tropical zones are inhabited by whole races of trees and shrubs; a rich crown of plants surrounds the plains of southern Europe; armies of green Gramineæ occupy Holland and Denmark; numerous tribes of Mosses are cantonned in Sweden; but the brownish-coloured Algæ, and the white and grey Lichens, alone vegetate in cold and frozen Lapland, the most remote habitable spot of earth; the last of the vegetables alone live on the confines of the earth."

The modifications in the distribution of plants which Linnæus had observed journeying from south to north, Tournefort had already observed during his travels in Armenia, upon the slopes of Mount Ararat. At the foot of this mountain he saw the plants of Armenia; higher up, he found the plants of Italy; higher up still, he found those of the environs of Paris; above these were the plants of Sweden; finally, on the borders of eternal snow, near the summit of the mountain, he found those of Lapland.

Buffon had also a glimpse of the laws which apply to the distribution of plants. "The vegetation which covers the earth," he says, "and which is still more closely attached to it than

the animals which browse it, are even more interested than they in the nature of climate. Each country, each changing degree of temperature, has its particular plants. We find at the foot of the Alps the plants of France and Italy; at their summit we find the plants of the frozen North; and the same northern plants we find again at the summit of the mountains of Africa. Upon the range of the hills which separate the Mogul empire from the kingdom of Cashmere, we find on the southern slopes many of the plants of the Indies, and it is not without surprise that we find on the north flanks many of those of Europe. It is also from the extremes of climate that we draw our drugs, perfumes, and poisons, and all the plants whose properties are in excess. Temperate climates, on the contrary, only produce temperate things; the mildest of herbs, the most wholesome of legumes, the most refreshing of fruits, the quietest of animals, the most polished of men, are the heritage of the mildest climates."

Such are the views with which men of genius and foresight preluded the discoveries of our times concerning the geographical distribution of plants.

At the commencement of the eighteenth century Geographical Botany was in a manner created by Alexander von Humboldt, whose genius is so universal that his traces are found in connection with every modern science. On his return from his voyage to the equinoctial regions of America, Von Humboldt, in one of his finest memoirs, demonstrated that it is the predominance of certain forms of vegetation which enables us to recognise a country immediately. A forest of Firs and Pines transports us at once to the northern or to the high mountain ranges of Europe; the Oaks and Beeches to the temperate zone; the Olives to the south, and the Palms into intertropical regions; the Cape of Good Hope is the country of the Heaths, and Mexico is perhaps the country most typical of the Orchids.

In another memoir Humboldt attempted to estimate the total number of plants diffused over the surface of the globe, and the influence of climate upon their distribution. For the first time he established clearly that localities, each equally distant from the equator, and at an equal elevation above the level of the sea, might nevertheless have climates very little resembling each

other, while countries situated under parallels very remote one from the other might have analogous climates.

The travels of naturalists of our own day in all parts of the globe have established, to the satisfaction of botanists, that certain characteristics belong to the vegetation of each climate, contrasts attending which we shall endeavour to convey to the reader some succinct idea. The researches of travellers, combined with the labours of descriptive botanists, enable us to give some precision to the principles of Botanical Geography.

Let us establish, before going further, the approximate number of vegetable species which inhabit our globe. The appreciation of the statistics of plants is necessarily very varied in this sort of estimate. Linnæus, in 1753, was acquainted with 6,000 species. Persoon, in 1807, reckoned 26,000. In 1824 Stendel carried the number up to 50,000; and in 1844 to 95,000. The most recent works contain about 120,000 species. From the species described botanists have been able to form some approximate estimate of the total number of existing species. By an ingenious calculation of the space occupied by an average-sized plant, Alphonse de Candolle thinks he may infer that the number cannot be less than from 400,000 to 500,000.

We have said that in 1844 we knew 95,000 species of plants. Of this number 80,000 were phanerogams, or cotyledonous plants, 15,000 were cryptogams, or acotyledons. Among the cotyledonous plants 6,500 belonged to the dicotyledons, and 15,000 to the monocotyledons.

Such was the general budget of the terrestrial flora at this date.

The numerical proportion of species belonging to the phanerogams or cryptogams, varies according to the latitudes of the globe. As we advance towards the north, the number of cryptogams increases; the number of phanerogams, on the other hand, increases as we approach the equator. In the frozen or temperate zones the cryptogamia are humble vegetables which scarcely raise themselves above the surface of the soil; but in the burning regions of the tropics, the elegant arborescent ferns rise to the height of the loftiest Palm-trees.

The vegetation of each species corresponds with a determinate interval in the scale of the thermometer, and this interval is not

the same for all plants. Meleze and Dwarf Birches resist cold of 40° Cent. below zero. While many of the Palms, the Orchids, and Tree Ferns die when the thermometer descends to 10°. While Alpine or northern plants subjected to the same temperature of 10°, fade and shrivel after a few days' exposure, other plants accommodate themselves to the burning sands of Africa, whose temperature may be from 60° to 72° Cent.

Another point of some importance to consider is the thermometrical degree at which each species begins to vegetate; thus the charming *Soldanella* of the mountains germinates and prospers at zero, while the Cocoa-nut-tree and other vegetables of the torrid zone remain unmoved until the temperature of 15° or 22° is attained.

Again, when vegetation has commenced, what is the temperature necessary to develop the flowers and ripen the fruits?

The Barley plant (*Hordeum*), the cereal which extends farthest towards the north, begins to vegetate when the thermometer ranges at 5° C. If, then, we would determine with precision the amount of heat which a plant must accumulate in order to accomplish its various processes of germination—budding, blossoming and fruiting, and maturing its fruit—it is not necessary to take account of the lower temperature, but adding the mean temperature of each day on which the thermometer has exceeded that degree, we find that in high latitudes the barley plant ripens when it has received an aggregate amount of heat equal to 1,500°. In order to produce death in wheat, an accumulation of heat equal to 2,000° is required. The vine, in order to produce a drinkable wine, requires the accumulated heat of 2,900° Cent., the point of departure being a mean heat of 10°.

We can now comprehend why certain vegetables live in some countries without flowering and others without bearing fruit. The short summers and short days in such countries fail to yield the aggregate amount of heat, and that supplied is just sufficient to develop their leaves, but not enough to expand their flowers; and their fruits are abortive. The influence of heat on vegetation is so marked that we can scarcely name a single species which is truly cosmopolitan. Most vegetables occupy a determinate zone of their own, which they rarely pass. The cold prevents them

from passing its limits towards the north; the heat exercises the same influence towards the south. All plants have their *polar* and their *tropical* limits.

Humidity of the atmosphere and the solar influence have, on the other hand, a notable influence on the geographical distribution of plants. It is still more necessary to consider the influence of elevation. In proportion as we rise in the atmosphere the temperature decreases, and this lowering of the temperature is so sudden, that in ascending a mountain we pass through many degrees of decreasing temperature in the course of a few hours. From this it follows that a high mountain under the equator may be clothed at its base in the richest vegetation, while its summit is covered with eternal snow, and the space between is clothed with all the diversity of vegetation (on a limited scale) which the traveller meets with in his journey from the equator to the pole.

With these general remarks upon the principal causes which influence the distribution of plants, we shall proceed to consider the botanical circumstances, namely, the zones of vegetation which result from them.

For botanical purposes we may divide the surface of the globe into three great zones:—1. The Torrid zone, which comprises the tropics between 24° north and south latitude. 2. The Temperate zone, which in each hemisphere extends from the tropics to the polar circle. 3. The Polar zone, which in the northern hemisphere includes all beyond the arctic, and in the southern all beyond the antarctic circle.

The Tropical zone, which receives the direct rays of the sun all but perpendicularly, is almost entirely exempt from winter. It includes the warmest regions of the globe. The year is there divided into two seasons—the one dry and burning, during which vegetation is sensibly suspended; the other the rainy season, during which vegetation revives. This large zone, which embraces in its circle continents, seas, and islands of all sizes, and which bristles with immense chains of the loftiest mountains in the world, presents climatal changes equally diversified, yielding productions which are very far from resembling each other. To render the subject clearer, it will be necessary to divide this zone into middle, temperate, and tropical zones.

The Middle, Tropical, or Equatorial zone, extends from the fifteenth north parallel to the fifteenth degree south latitude. The two others are the Tropical zones, properly so called, ranging on each side the Equatorial zone up to the twenty-fourth parallel north and south.

The two Temperate zones are contiguous on the one side to the Torrid zone, and on the other to the frozen regions of the Pole, extending over a space of forty-two degrees of latitude. Like the Tropical zones, they present great varieties of climate and of vegetable products. These zones we also subdivide in a botanical point of view into four secondary zones, namely, the Juxta-tropical, the Warm Temperate, the Cold Temperate, and the Arctic zone. The Polar zone comprehends the polar regions, which extend from 60° to 80° north latitude.

We shall not follow in our few remarks the order of these natural regions, and we feel that the motives for this determination are justified by the following remarks of Alphonse de Candolle. "I hold," says the learned Botanist of Geneva, "I hold the divisions of the globe by regions first proposed as artificial systems in great part. The laws respecting them are much too arbitrary, and the regions indicated are neither like each other in the majority of books, nor are recognised by the greater number of botanists." We think it simpler, in place of dwelling upon these natural regions, upon which botanists are by no means agreed among themselves, to consider apart, in order to give a general idea of their vegetable products, the five geographical divisions of the whole world—Europe, Asia, Africa, America, and Australia.

Europe.

We can distinguish in Europe three great botanical regions. 1. The region of the North. 2. The Middle region. And 3. The region of the South, or Mediterranean.

The Northern region comprehends Lapland, Iceland, the northern provinces of Sweden, of Norway, and of Russia. The vegetation there is monotonous, with little variety. The ligneous species form only one hundredth part of the plants we find there. The cryptogamous plants predominate. The trees are principally represented by Conifers and Amentales, with some

light and accidental exceptions. The Oaks, the Hazel, and Poplar are arrested at the sixtieth degree of latitude north; the Beech, the Ash, and the Lime at 63°; the Conifers grow up to 67°; Barley and Oats can be cultivated up to the seventieth parallel

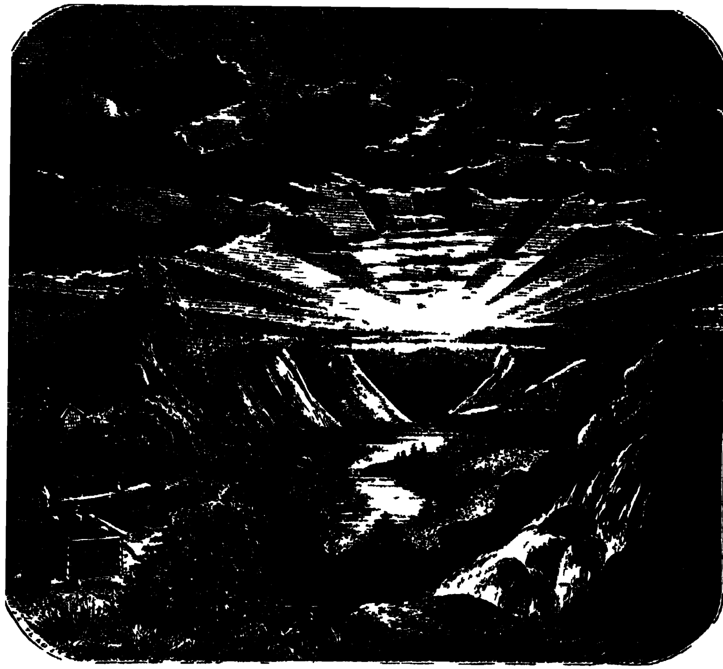


Fig. 446. Norwegian Fjords.

north. Spitzbergen, the most northerly island in Europe, situated between 76° 30′ and 81° north latitude, contains only ninety-three species of phanerogamous plants, belonging principally to the families of Gramineæ, the Myrtaceæ, a few Cruciferæ, Saxifrages, Ranunculaceæ, and some Synantheraceæ. Among these plants there is scarcely a single tree or shrub, but only an under-shrub, *Empetrum nigrum*, and two small creeping Willows. Some idea of Norway, with its deeply intersecting fjords, may be gathered from the engraving, Fig. 446.

Mr. Charles Martins, the learned Professor of the Faculty of

Montpelier, to whom Botanical Geography is indebted for many fine observations, made a voyage along the western coast of Norway, from Drontheim to North Cape, in recording which he has traced with a vigorous hand the picturesque vegetation of that country. "On the 28th of June," he says, "we arrived at Drontheim. While embarking I was much surprised to see Cherry-trees bearing fruit about the size of peas. Lilac, the Mountain Ash, the Black Currant Bush, and the *Iris germanica* were covered with expanding flowers. My astonishment ceased, however, when I learnt that the spring had been a very fine one. The most common tree in the gardens and streets of the town is the Mountain Ash. I remarked also four Oaks (*Quercus robur*), which appeared to suffer from the cold. In short, upon the west coast of Norway the northern limit of the oak lies half a degree south of Drontheim.

"The Ash is a more hardy tree, but it never attains the dimensions of the Oak in Sweden, and in latitude 69° 18′ I noted the last of them. The Lime lives at Drontheim, as does the Poplar, the Blue Melilot, and the Chestnut-tree. The Common Lilac blooms in every garden. All fruit-trees are cultivated on espaliers. Even on the most favoured exposures, the apple, pear, and plum do not ripen every year. In the environs of Drontheim bouquets are formed of Elder blossom, of Birch blossom, and Fir tops, intermingling with the Ash, Maple, and Aspen; Cherry blossom, Hazels, and Junipers crown the pyramid. The upper fields are dry and well exposed, while the meadows occupy the lower ground. This fine fresh landscape has something exceedingly pleasing about it, although severe and cold.

"Towards the north I pushed on to Cape Ladehamer, which is crowned with light foliaged Birches. On the east is the cascade of Leerfes, where the accumulated waters of the Nidelven precipitate themselves over the rocks in the middle of a black forest of Pines. I arrived there at midnight. The sun and its surrounding rays, which mingled together on the horizon, projected a hazy doubtful light upon the landscape, for at this period of the year the sun scarcely sinks beneath the horizon in this latitude, and the scattered lights which burn in the heavens towards the north already announce that it will soon reappear.

"In the fields and by the roadsides I found a great many plants which occupy similar situations in France." "Nevertheless," he continues farther on, "the eye of a botanist was rejoiced by the sight of a vegetation belonging at once to the flora of the Boreal regions, of the Alps, and of the sea-shore."

Among the shrubs he discovers the *Geranium sylvaticum*, the Alpine Columbine, the *Aconitum septentrionale*, the *Pedicularis* of Lapland, the *Trientalis Europæa*, the four-leaved *Paris*. In the more sheltered places were the Dogberry of Sweden, the *Vaccineum vitis idæa*, the renowned viviparous Alpine Pea; in the marshes the Bilberry, the *Avens*, or Herb Bennett of the brooks; upon the sandy sea-shore the Water Plantain (*Triglochin maritimum*), and many others equally interesting to the botanist.

In the first days of July the traveller reached Heldringen, a post town situated on the borders of Northland and the Government of Drontheim, under latitude 65° 15′. He scaled a mountain whose denuded summit was 2,100 feet above the level of the sea. Its vegetation resembled that of the summit of the Alps. The Willow and the *Diapensia* of Lapland alone reminded him that he was in Norway.

"At Bodoé, in 67° 16′," he continues, "I saw for the first time houses covered with turf, upon which grew many tufts of grass. According to my custom, I first examined the cultivated vegetables, but I saw only a few Potatoes, Peas, Radishes, a few Gooseberry-trees without fruit, and some fields of Barley and Rye.

"In the meadows just above the sea-level I found some plants which would have demonstrated to me, in the absence of other proofs, how much the climate of this country approaches that of the most elevated Alpine regions. This was the eight petalled Dryas, *Silene acaulis*, *Arctostaphylos Alpina*, Ladies' Mantle, and the *Bartsia* of the Alps; and beside them, those vegetables of the northern regions which are unknown in Alpine regions, namely, *Aconitum septentrionalis*, the white *Draba*, the *Tofieldia Alpina*. Besides these, notwithstanding the difference of climate, some of the plants which are most common in the neighbourhood of Paris are found here, as the Dandelion, the Coltsfoot, Tussilago, the Meadow Cardamum (*C. pratensis*), the Dog's-tooth Violet; they

seemed a souvenir of France thrown at random in the midst of this Borean vegetation."

He arrived finally at Hammerfest, which is under 70° 48′ north latitude. Here all attempts at cultivation had disappeared. The energies of the place are turned to commerce; it is from curiosity rather than for profit or utility that a few legumes are cultivated."

"Near the city," adds the Professor, "I observed rich meadows, that were cut once a year, and some herds of half-wild reindeer, which grazed and roamed about freely. We shall deceive ourselves, however, if we consider Hammerfest a dull or melancholy city. Its principal street, on the contrary, consists of very fair new wooden houses, well ordered, and in all respects comfortable. These are the habitations of the better class of inhabitants. The houses of the lower classes are poorer and older; borrowing, however, a particular charm from the flowery turf with which they are covered. The roofs are formed of great squares of turf, on which a number of plants have germinated and grow vigorously. In seeing these aerial gardens I have for the first time been able to comprehend the phrase '*in tectis*,' which often occurs in the writings of Linnæus, indicative of the locality. In short, it was upon the roofs of houses that the learned Botanist of Upsal herborised at Hammerfest; indeed, I frequently borrowed a ladder myself from the proprietor in order to gather the plants which grew round the chimney of one of these picturesque old houses. What I often found there were *Cochlearea Anglica*, *Lychnis sylvestris*, *Chrysanthemum inodora*, Shepherd's Purses, *Thlaspi*, and Field and Meadow Peas. In autumn, when the yellow flowers of *Chrysanthemum inodorata* are in full bloom, these hanging meadows rival in beauty those of our own more genial climate, and give the city a smiling physiognomy which contrasts most happily with the severe aspect of surrounding nature. The *Ranunculus glacialis*, *Arabis Alpina*, *Silene acaulis*, the Snowy Saxifrage, a few Bilberries, the Drapensia of Lapland, some dwarf Willows, as *Salix reticulata*, *herbacea*, &c., all grow in the neighbourhood."

The learned traveller finally reaches North Cape, in latitude 71°. "How great was my surprise on landing," he continues, "to find myself in the middle of the richest subalpine meadows that can be imagined! High and tufted grass, which reached my knees.

I found here, in short, at the northern extremity of Europe, the flowers which had so often attracted my admiration at the foot of the Swiss Alps; there they were, as vigorous, as brilliant, and all much larger than among the mountains. The Globe Flower of Europe (*Trollius Europæus*), the *Alchemilla Alpina*, Geranium of the Woods, the Alpine Hawkweed, *Hieracium Alpinum, Phleam Alpinum*, and the Alpine Pea. On the right rises the imposing mass of North Cape, steep and inaccessible; before us a steep and sloping, but verdant path, which permitted us to attain the summit by winding round the side of the mountain. In the descent I gathered with enthusiasm all the plants which presented themselves; to me they possessed a peculiar interest as being, so to speak, the most robust and adventurous of all their European congeners. They seemed, like myself, to be expatriated, and exposed on this black rock to be battered by the waves. I was tempted to ask them why they had quitted the skirts of the cultivated fields and peaceful shades of the woods of Meudon, where they could receive the homage of Parisian Botanists, in order to lead this exposed life among strangers? They were the Meadow Queen, the Cerastium of the fields, Shepherd's Purse, *Dandelion leontodum*, Golden Verge, &c. Nevertheless the Boreal or Alpine plants were in the majority on these slopes. I found there *Pedicularis laponnica, Salix reticularis*, the Snowy Gentian, *Cornus alba*, the Dogwood-tree of Sweden, &c.

"The loftiest summit of North Cape is 1,020 feet above the level of the sea; it is surmounted by a small rock, on which many visitors have engraved their names. But even this last rock was not destitute of all vegetation; the small circular leaves of *Parmelia saxitilis*, one of the Lichens, black as the rock, were attached to it, and a small microscopic moss hid itself in the clefts upon the plateau. There were a few miserable looking plants which had been destroyed by the winds, scattered on the ground and seeking shelter behind such elevations of the soil as would protect them from the continuous squalls which swept the North Cape. Among the shrubs I even found the Birch and the *Chamæledon procumbens*. The herbaceous plants were much less numerous. Among them were *Silene acaulis*, the *Diapensia laponnica*, and the opposite-leaved Saxifrage.

The Middle European region includes all the countries which constitute the southern provinces of Europe—Germany, Holland, Belgium, Switzerland, the Tyrol, and the British Isles, Upper Italy, and the greater part of France. This region, whose exact limits it would be difficult to trace, is very different from the preceding. It is milder, more temperate; its woods and forests consist essentially of the Common Oak (*Quercus robur*), to which we may add the Chestnut-tree, the Beech, and the Birch, the Elm, the Hornbeam, the Alder, &c; but the Oak predominates. Those trees, all of which lose their leaves during winter, give to the landscape a very peculiar feature, varying with the season. This region is especially favourable to the cultivation of the Cereals. An oblique line, drawn from the east to west, with certain inflections of its course, but ranging between the forty-seventh and forty-eighth parallel, and inclining a little towards the north, would divide the two zones—one, the Northern, in which the Vine and the Mulberry yield to the rigour of winter, whose forests are chiefly composed of Conifers, where the culture of the Apple and the Pear take their place, and which includes more of the Cyperaceæ, of the Rosaceæ, and of the Crucifers; the other, the Southern, characterised by the culture of the Vine, the Mulberry, and the Maize, and in which plants of the Labiatæ begin to predominate. Some idea of the vegetation of this region will be gathered from Plate XIX., which represents the banks of the Loire in the glory of its summer vegetation.

In the Southern European region the Mediterranean forms the centre. It is a vast basin, whose shores present a vegetation which, if not identical, is at least analogous in its whole extent. The Labiateæ abound there, and in certain seasons the air is filled with their sweet perfume. To this extensive family we may add a large number of Caryophyllaceæ, Cistaceæ, Liliaceæ, and Borragineæ. The Mediterranean draws its most distinctive character, however, from the vast extent of uncultivated country, where the Kermes Oak, the *Phyllereas*, the Evergreen Oak, and various Labiateæ, half frutescent, reign supreme. These plants more especially abound in Italy, Spain, Greece, Algeria, and in the northern portion of Asia Minor. Nevertheless a new vege-

tation makes its appearance at Rhodes and Jaffa, which becomes closely connected with that of Egypt.

The vegetation of the Mediterranean often presents itself with a smiling and agreeable aspect. Clumps of odorous Myrtles and Arbutus, the aromatic Charte-tree, frequently occur on its shores; magnificent Rose Laurels, whose praises have been sung by the poets, occupy the edges of the brooks. In Italy, Sicily, and Spain, the Orange trees form almost one mass of flowers and fruit. The Prickly Pear (*Opuntia vulgaris*), the African species of Agave, become here indigenous, forming impenetrable hedges in the southern parts of these countries, to which they give a marked and very characteristic landscape. The forests consist essentially of the Evergreen Oak (*Quercus ilex*), whose persistent leaves remain until after their third year, and whose acorns, which have a very agreeable taste, form a considerable portion of the people's food. The Cork-tree (*Quercus suber*), mixed with other characteristic trees and shrubs, such as *Erica arborea*, with numerous species of *Cistus*, with ephermal flowers, often large and of dazzling brilliance, mingling with the fragrant *Geneta*, or Broom, form the ordinary vegetation.

Among the other species characteristic of the vegetable world of these happy regions we may cite the Cypress (*Cupressus*), the Aleppo Pine (*Pinus lariceo*), some Plantains, the Olive, which we scarcely meet with elsewhere; Mastic-tree (*Pistachio seritiscus*), and the Pomegranate.

Over a great part of the south coast of Sicily, a Palm, the *Chamærops humilis*, with fan-like foliage, waves beside the Date, sometimes from the bosom of a clump of Oranges and Citrons, its tall stipe crowned with an elegant panicle of drooping and feather-like leaves.

Asia.

It would require a volume to give even an idea of the rich and varied vegetation of Asia. We must limit ourselves to a rapid glance of the features most characteristic of its northern, central, and southern divisions.

The Northern region, of which Siberia is a part, forms a botanical region in close connection with the hyperborean

portion of Europe in the one direction, and with its middle region on the other. It has its own peculiar character, nevertheless, from the predominance of certain families, such as the Leguminoseæ, Ranunculaceæ, Crucifers, Siliaceæ, and Umbellifers, some genera of which are remarkable for the number of their species. We may quote genus *Astragalis* among the Legumes; the *Spiræa* among Rosals; the *Artemisia* among the Compositeæ; and the Rhubarb among the Polygonaceæ. Considering the mean annual temperature which ranges there, from 2° to 6° above zero, we cannot reckon on a condition of vegetation very varied. Leafy forests are formed by the Siberian Larch, the Daurique Larch, the Siberian Pine, the Cimbrian Pine, and *Pinus sylvestris*, &c.; White Poplars and isolated Balsamic plants, some species of dwarf Birches, Service trees, Blackberries, Alders, Willows, accompany them, while Myrtles and Alpine Roses form the under-shrubs. The Flora of the Steppes of Kamtschatka does not differ materially from that of the pasturages of central Europe. According as the spectator expects these to be rich or sterile, he is the more or less surprised to find stately Tulips and graceful Irises mingling with the grassy turf in spring, but the Absinthe, or Wormwood, *Artemisia*, and other monotonous forms of vegetation, succeed them.

Humboldt assigns to the forests of the Ourals the vegetation characteristic of a park. "They present," he says, "an alternation consisting of a mixture of Aceraceæ, round-leaved plants, and other magnificent trees; an assemblage which is completed by masses of brushwood, formed by Wild Roses, Honeysuckles, and Junipers, whilst the *Hesperis*, the blue-petalled *Polemonium*, *Cortusa*, *Mathiola*, magnificent Primroses, and Larkspurs, form a perfect carpet of flowers; while the Water Trefoil, with white blossoms and delicately carved leaves, is the grace of the marshes." He saw also "on the banks of the Irtisch great spaces entirely coloured with red by *Epilobium*, with which were associated the tall-stemmed Larkspurs (*Delphinium*), with blue flowers, and the fiery-scarlet *Lychnis Chalcedonica*."

These fragmentary pictures, which we borrow from Muller's "Wonders of the Vegetable World," give an idea very different no doubt from that usually entertained of the vast regions included in Northern Asia.

In Central Asia we are transported into the vast regions lying between the Himalayas and China, including Japan.

The Magnolias: these grand-leaved trees, with magnificent flowers and delicate aroma, which give such an attractive feature to gardens where they can be cultivated, are natives of this vast region. So is the Camelia, which has been as it were naturalised in the greenhouses of Europe, whose evergreen, glossy, and persistent foliage is the admiration of travellers, and of which we may reckon upwards of seven hundred varieties of the *Camelia Japonica* alone; and the Tea plant (*Thea virides*), of whose precious leaves, so many millions of pounds are annually imported into Europe. Also the *Aucuba,* with coriaceous leaves and clustered flowers, so ornamental in our gardens and shrubberies. Finally the genus *Celastrus,* Hollies, Spindle-tree (*Lagerstiæmin spiræ*), &c.

The most remarkable trees and shrubs besides these are the elegant Palm (*Rhaphis flabeliformis*); the Paper Mulberry (*Broussonetia papyrifera*); the fragrant Olive (*Olea Europæa*), whose flowers are employed to give flavour to Tea leaves; the Ebony tree (*Diospyros kaki*), with white flowers, and berries of a cherry-red, and of a delicious flavour; the Japan Medlar (*Mespilus Japonica*); the *Ginko biloba,* or Sacred tree, which is planted round the temples; the Yews (*Taxus mucifera* and *verticulata*); the Cypress (*Cupressus pendula*); some Junipers, Thujas, and Oaks—among the latter, *Quercus glabra* and *glauco;* the *Alnus Japonica, Juglans nigra* (the Black Walnut), and several species of Laurels and Maples.

Among the cultivated plants we find Rice, Wheat, Barley, Oats, *Sorghum saracina,* Sago-tree (*Cycas revoluta*); the Caraibian Cabbage (*Caladium esculentum*); *Convolvulus batatas,* the Apple, the Pear, Quince, Plum-tree, Cherry, Apricot, Peach, Medlar of Japan, divers species of Orange, Cabbages, Radishes, Yams, Cucumbers, Gourds, Water-Melons, Anise (*Pimpinella anisum*), Peas, Haricot Beans, Hemp, Paper Mulberry, Annual Cotton plant (*Gossypium herbaceum*)—a remarkable mingling of vegetable production which transports us at one moment from Asia to Europe, and at the next from Europe to Asia.

The same curious assemblage of the vegetation of the tropics with that of the North of Europe occurs again in respect to culti-

vated plants in Central Asia. We see here, side by side, the Fig, the Vine, the Chestnut-tree, and the Pomegranate, the Almond and the Citrons. In China and Japan we find under cultivation the *Sarracenia*, Wheat, Barley, Oats, Potatoes, Asparagus, Melons, Peas and Beans, and, along with them, Rice (*Arum esculentum*) and Indian Corn. We might here dwell upon a crowd of ornamental plants, many of which are now well known in Europe, such as *Glycine*, the Lily of Japan, the Tiger Lily, the Chinese Primrose, and the Magnolia, which are native in Russian Asia, and well-known ornaments of our hothouses.

The Southern region of Asia comprehends the Indian peninsula. Here non-tropical species disappear, or only present themselves very rarely. Tropical groups become more numerous; the trees cease to lose their leaves; ligneous vegetation is much greater than it is without the tropics; the flowers are larger, more magnificent; climbing creeping and parasitic plants increase in number and size. India may be considered the true country of aromatic plants. Nor is the rich soil less fruitful in the production of plants of another order. Trees producing suitable timber for constructive purposes are found there in perfection.

Among the arborescent plants those most abundant in this botanical region are found to belong to the genera of *Bombax*, *Sapindus*, *Mimosa*, *Acacia*, *Cassia*, *Jambosa*, *Gardenia*. The Ebony-tree (*Diospyrus ebenum*) has been celebrated for its black coloured, solid wood from the most ancient times. The Bignonia (*Tectona grandis*) is a magnificent tree, which furnishes timber well adapted for building purposes from its great endurance. *Isonandra gutta* produces the substance analogous to caoutchouc, which is known as *Gutta-percha*. The Laurels have an aromatic bark. The Nutmeg-tree (*Myristica*) produces seeds which are employed as spice. The Figs (*Ficus religiosa*, *Indica*, *elastica*); Palms, such as the Borassus (*Borassus flabelliformis*), whose magnificent leaves extend in large fan-like panicles; the *Sagus*, whose soft pulp yields sago, a farinaceous product very rich in amidon; the *Calamus*, whose twining and creeping stem is sometimes upwards of five hundred feet in length, and of one uniform thickness, and of which many canes used in Europe are made. The Areca (*Areca catechu*), the nut of which is a favourite masticatory

with the natives; the *Corypha umbraculifera*, the trunk of which, sometimes reaching the height of sixty or seventy feet, is crowned with an ample tuft of leaves spread out in umbrella form, covering a space of eighteen feet; the Dragon tree; the Screw-pines (*Pandanus*); the Bamboo, and many others, equally noted for their size and properties, are natives of this region.

If we throw a glance, moreover, at the plants under cultivation, we find them equally important:—Rice; the Earth Nut; *Sorghum;* Indian Corn; the Cocoa-nut Palm, the elegant and useful tree which gives to man almost all the necessaries of life, supplying him at once with shelter, food, light, heat, and clothing; the Clove-tree (*Caryophyllus aromaticus*), the flower of which is the well-known clove; the Pepper shrub (*Piper nigrum*), the fruit of which, gathered before maturity, constitutes the pepper which has been constantly brought to Europe since the expedition of Alexander the Great; and the Betel Pepper (*P. Betela*), with bitter and aromatic leaves, in which the Southern Asiatics enclose a few slices of the Areca nut, which they chew to sweeten the breath and stay their hunger; the Tamarind (*Tamarindus Indica*), a magnificent tree, the fruit of which encloses a pulp of vinous odour and tartish flavour; the Mango (*Mangifera Indica*), whose much-vaunted fruit has a sweet and richly perfumed flavour, accompanied with a grateful acidity; the Mangostan (*Garcinia Mangostana*), whose berry encloses, under a bitter and astringent epicarp, a delicious pulp, having a happy mixture of the tart and sweet; the Banana-trees (*Musaceæ*), of many species, whose yellow clustered fruit, each six or eight inches long, furnish a very nourishing food, which has the taste of buttered paste, slightly sugared, while its leaves form a delicate vegetable, and its fermented juice an agreeable wine; the Schambu (*Jambosa vulgaris*), whose small apples communicate to the mouth a rose-like odour; the Guava (*Psidium pomiferum*), with yellow fruit of the size of a Pear; many Oranges; Water-Melons; Sugar-cane, and the Coffee shrub, are all found among the number.

We have attempted in Plate XX. to give an ideal representation of the principal species of vegetables belonging to the botanical region which we have just described. Some rustic species are figured in the foreground. On the left of the picture

is the *Corypha*—Palms which rise in their native climate to the height of a hundred feet. On the left is the *Arenga saccharifera* and a group of Bamboos. Towards the centre, but still on the left, and near the trunk of a great Sandal-wood-tree, the *Sinapus*, surmounted by the Sago-tree (*Raphis flabilliformis*). In the middle distance is the Areca Palm, its stem intertwined and surrounded by embracing Lianes. On the right is the Palm *Borasses;* close by is the Banana; both in the shade of a large Mango-tree, the Cinnamon Laurel. All this group is backed by a lofty Cocoa-nut tree.

The vegetables cultivated in the background are—the Pepper-tree (*Piper*), the Camphor-tree (*Cinnamomum camphora*), behind the Cocoa-nut-tree, and in the distance the Nutmeg and the Pepper-tree, near a row of Bamboos and Rotangs.

Africa.

Africa, like Asia, presents three very distinct divisions:—1st. Northern Africa, which comprehends the Mediterranean and Sahara region; 2nd. Central Africa, which is tropical; 3rd. South Africa, which includes the Cape of Good Hope.

The Mediterranean region, by which we mean the African littoral bathed by the Mediterranean, includes Algeria from the southern slopes of the Atlas to the sea, and the countries washed by the Delta of the Nile. This part of Africa presents, in many respects, a vegetation analogous to that of South Europe. By its close affinity with the corresponding European countries, Algeria would seem to be a natural centre of colonisation, the region of cultivation, its rich produce in cereals making it a granary of abundance to European countries. In the mountain region of North Africa all the plants of Central Europe may be cultivated with advantage. The Vine prospers in the neighbourhood of Tlemcen Milianah, Mascare, and Medeah, where the colonists and even the natives have undertaken its cultivation. The Olive, so generally spread over North Africa, constitutes one of their chief sources of wealth to the Kabyle tribes. The Cork-tree forms immense forests in the interiors of the mountain region of the littoral: in the province of Constantine, gathering in the bark of the Cork-tree has become

an important trade since its conquest by France. On this subject M. Cosson, a traveller and botanist, thus expresses himself:—"The natural region of Northern Africa is especially characterised by the extreme rarity of rains, the dryness of the atmosphere and the extremes of temperature; the absence of great ranges of mountains and of permanent water-courses give an aspect quite special to this desert-like vegetation. The number of vegetable species growing spontaneously does not exceed five hundred. The greater number of these are perennials, which grow in tufts, and have a dry and sterile aspect, giving them a rugged and hard appearance, which is quite characteristic. The families represented in the Algerian Sahara in greatest number are the Compositeæ, the Gramineæ, the Leguminoseæ, the Cruciferæ, and the Solanaceæ. Among the Ligneous species are the Tamarix, a genus of elegant flowering shrubs, and the Mastive-tree (*Pulmia Atlantica*). The Date-tree is, however, the chief source of wealth in the gardens of the Oasis. This tree is cultivated not alone for the abundance and variety of its products, but also for its shade, which secures other cultivated plants from the violence of the winds, and maintains in the soil the moisture required for the cultivation of other crops.

"Besides the Date, the Oasis generally presents an abundant crop of Figs. Pomegranates, Apricots, and frequently the Vine; the Peach, the Quince, the Pear, and the Apple, are invariably planted in the gardens of the Ksours, and in the Oasis situated near the hills. More rarely we meet in the Oasis, the Orange-tree, Olives, Barley, and more rarely still, Wheat, which is cultivated in the irrigated lands of the neighbourhood in the intervals between the Date plantations. Onions, Beans, Carrots, Rape, and Cabbages, occupy a large place among the plants cultivated. Pimento is also largely cultivated for the stimulating properties of its fruit, which render it a favourite condiment with the Arabs. The Egg plant, or Mad Apple, and the Love Apple (*Lycopersicum esculentum*), are cultivated in some gardens for their fruit. Numberless species of Cucurbitaceæ are also sown in the gardens in summer, and sometimes attain a great size. The Gombo (*Hibiscus esculentus*) is cultivated here and there for its mucilaginous fruit. The industrial and fodder plants are principally Hemp, repre-

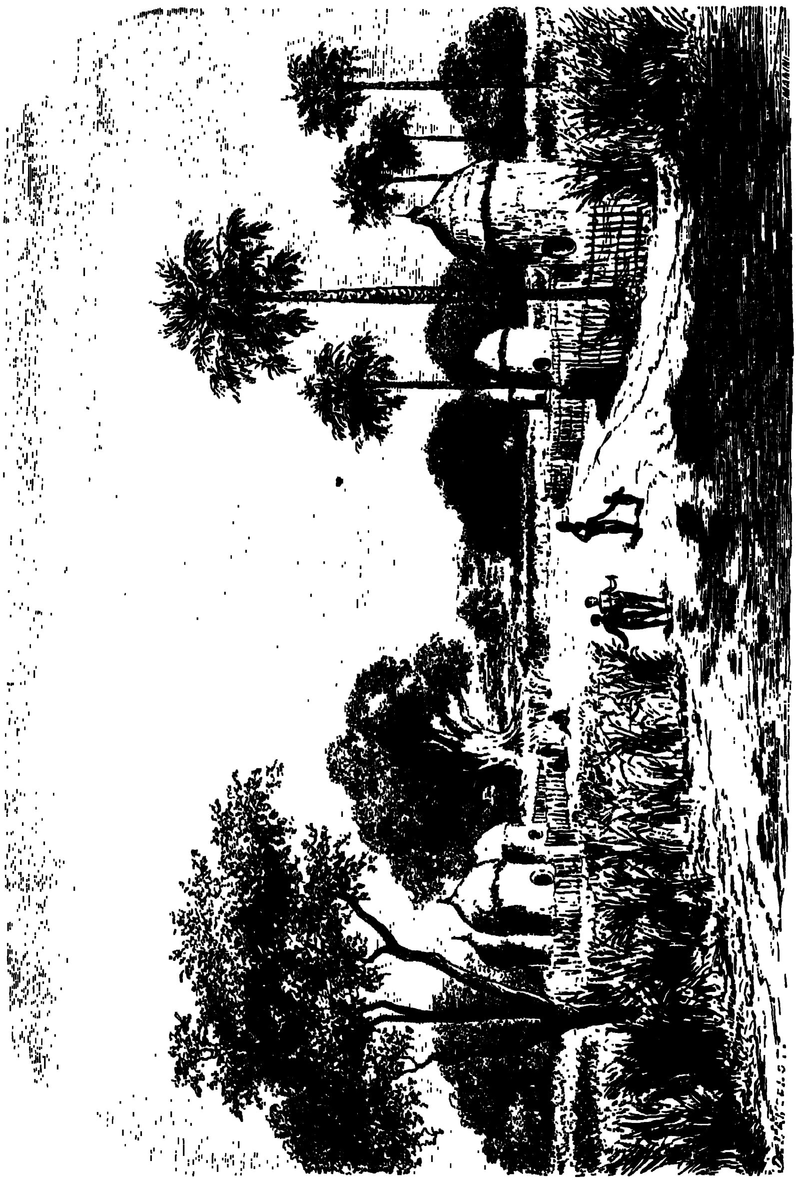
sented by a dwarf variety called Haschich, which is employed as a textile plant, and its extremities are smoked by some of the less fervent Mussulmen. Tobacco is also cultivated. Henne (*Lawsonia inermis*), the leaves of which have been employed as a black colour in painting, is only cultivated in the Oasis of Zeban."

Equatorial Africa is only very imperfectly known, in consequence of the terribly insalubrious nature of its coast. The same forms of vegetation, however, prevail there which are found in other tropical regions. We may remark here that the plants, which are usually herbaceous in countries without the tropics, become ligneous in these regions. This is the case with plants of the families of the Rubiaceæ and the Malvaceæ. We note here also the almost entire disappearance of the Cruciferæ and the Caryophyllaceæ. The prevailing families are the Leguminoseæ, the Terebinthaceæ, the Malvaceæ, Rubiaceæ, Aranthaceæ, Capparidaceæ, and Anonaceæ.

If we take a glance at prevailing vegetation proper to this region of Africa, we find upon the humid coasts impenetrable forests formed of Mangroves (*Rhizophora mangle* and *Avicennia tomentosa*), Plantain-trees (*Musa, Amomum*), odd-shaped Pandanaceæ, gigantic Malvaceæ (such as the Baobab), some Bromeliaceæ *Aroïdeæ*, and Aloes. Among others is *Aloe Socotrina*, which furnishes the Aloes of medicine. This and several fleshy Euphorbias impress their strange characteristics upon the vigorous vegetation of this region.

It would be depriving African vegetation of its richest ornament not to mention its admirable Palms. At their head stands the Olive-like Palm (*Elais guineensis*), the fruit of which, of the size of an Olive, contains so much oil that the liquid flows out when it is pressed between the fingers. The seed contains a sort of butter. The sap of this precious tree yields an excellent wine; its leaves prove excellent food for sheep and goats, and its fruit the best Palm-oil. But the true Palm wine is produced from *Sagus vinifera*. Another of this elegant family of Palms is *Lodoïcea Leckellarum*, the fruit of which is larger than a man's head, and weighs upwards of twenty pounds; it sometimes floats as far as the coast of India.

It is a fact worthy of remark that in this region very few Ferns



or Orchids are observed, and yet these groups of plants are extremely numerous in other tropical countries.

Among the Exotic vegetables which are successfully cultivated in Central Africa we may reckon Maize, Rice, Sorghum, Indian Corn, Manioch, the *Caladium esculentum*, or Caraibian Cabbage, a plant belonging to the family of the Araceæ, the rhizome and leaves of which are alimentary; the Banana, the Mango, and the Papaw-tree (*Carica papaya*), the fruit of which, about the size of a small Melon, is eaten either raw or cooked, and the pulp, mixed with sugar, forms a delicious marmalade; also the Ananas, Figs, Coffee shrub, Sugar-cane, and Ginger, divers species of Haricots, and various species of Dolechos, the Earth-nuts, Cotton plant, Tobacco, and Tamarinds. Plate XXII., which represents an Abyssinian village, will give some idea of the vegetation of Equatorial Africa. Alongside the lofty Palms and Adansonias we see here the usual arrangements for cultivating rice.

South Africa, the region of the Cape of Good Hope, is the country of the Proteas, Pelargoniums, Epacrideæ, Oxalids, and Ixias, numerous species and endless varieties of which decorate our hothouses and parterres. No other country can compare with this region for the prodigious abundance and dimensions of its Heaths. It is their true country. While the plains of Europe, the Alps included, can scarcely point out half a dozen species, at the Cape there are many hundreds. They attain sometimes the height of fifteen or sixteen feet. Their leaves are small, inconspicuous, and aricular; but their flowers are sometimes very grand, and the colours which decorate them brilliant in the extreme, varying from the softest shades to everything that is dazzling.

The Flora of this region is rich in vegetable forms, but it is by no means smiling in its aspect. We find no true forests, grand and sombre, in the whole region; there are few creeping plants, but, on the other hand, there are many grass plants. The most characteristic families are the Restiaceæ, Irideæ, Proteaceæ, Ericaceæ, Ficoïdes, Drosma, Geraniaceæ, Oxalideæ, Polygals. Among the various species we may mention the Ixias; the Gladioles, with their sword-shaped leaves and parti-coloured flowers; the Strelitzias, so remarkable for their inflorescence and for the odd division of their blue and yellow flowers; the Proteas, so named from

their diversity of appearance; the Leucadendrons, of which one species, *L. argentium* (the Silver-tree), rises to the height of from thirty to forty feet, its branches charged with lanceolate leaves nearly white and silvery, and of silky appearance, with heads of bright yellow flowers; the *Ericeæ*, with rigid, evergreen, whorled leaves, and monopetalous flowers, of which this seems to be the natural home. We may add to our summary the Helichrysums and Gnaphaliums, the corymbiferous composites, better known as *Immortelles;* the Mesembryanthemums, or Ice plants; the Stapelias, of grotesque appearance, with star-like flowers; the leafless Asclepiads, with angular fleshy stem and showy flowers, but somewhat fœtid odour; the Phylicas, a genus of Rhamnads, somewhat resembling Heaths, with abundant evergreen foliage flowering in small cottonous heads of white flowers; and last, by no means least, the Pelargoniums, of which an infinite variety, the result of culture, are known. Add to these the Oxalids, the evergreen *Sparmannia,* whose white flowers, stamens with purple filaments and irritable anthers, are so ornamental in Orangeries.

It is upon the sandy coast of this curious botanical region that such plants as the Stapelias, Irideæ, Ice plants, and Diasmos abound. The Heaths and Crassulads grow upon the slopes of the mountains.

The cultivated plants are the Cereals, most of the fruits and legumes of Europe, the Sorghums of Caffreland, the Banana, the Tamarind, and the Guava-tree.

America.

Vegetation is richer and more varied in America than in any other part of the globe. Beginning with North America, we find its Polar vegetation quite analogous to that of Europe and Asia under the same latitudes. The same kind of trees are found there. The Willow, Birch, and Poplar, exposed to the persistent action of the cold, become stunted bushes; and even the same herbaceous forms of Saxifrages, Mosses, and Lichens prevail.

Without dwelling on the Arctic regions, then, we may divide this immense country into two regions: one of which, descending as far as 36°, may be called the Northern region; the other, com-

prehended between 36° and 30° of latitude, will constitute the Southern region.

The Northern region of America well deserves to be called the region of the Starworts and the Golden or Copper Birches (*Solidago*); those beautiful composites abound there with the genera *Liatrus*, *Rudbeckia*, and *Gaillardia* of the same family. The Œnotheras, Clarkias, Andromedas, and Kalmias, charming ornamental plants, well known in our flower gardens, likewise characterise this vegetable zone. Amongst the most abundant species, we may mention the numerous species of Pines, Firs, Larches, Thujas, Junipers; no less than twenty-seven species of Willow, twenty-five others consist of Oaks, Beeches, Chestnuts, Wych Elms, and Hornbeams, Alders, Birches, Poplars, Ash, and Elms, with which are mingled the American Plane; the Liquidambars, the trunk and branches of which furnish juices used in medicine; the Tulip-tree, with singularly truncate leaves and large, spreading, solitary, yellowish flowers; different species of Maples, Lime-trees, Robinias, and Walnut-trees. Together with these numerous and varied arborescent species, which attain considerable dimensions, grow the *Myrica cerifera*, which furnishes an abundant wax drawn from the fruit by boiling; the Currant bush (*Ribes*), with coloured and ornamental flowers in great varieties of red, yellow, and white; the elegant Andromeda, Azalea, Rhododendron and Meadow Sweet present themselves in endless varieties; Sumacs, a species of which (*Rhus toxicodendron*), with greenish yellow flowers, contains a juice so acrid that contact with it produces blisters and erysipelas, and others a dangerous poison; with Ceanothus, Hollies, and Blackberries.

The Southern region is comprehended between 30° and 36°; its vegetation somewhat resembles that of the tropics, being a transition between the temperate and torrid zones. Walnuts, Wych Elms, Chestnuts, and Oaks are found there, and alongside of them three specimens of Palms,—the *Chamærops palmetto*, the terminal buds of which form a delicious legume; some *Yuccas*, some *Zamias* among the Cycadeæ; some Passifloras, woody twining plants, such as *Bignonia Sapindus*, Cactuses, Laurels. Lastly, by the side of the Tulip-trees, Pavias and Robinias, grow magnificent Magnolias, of which this is the true domain. The vegetation of this region is thus remarkable in its variety. The

Sugar-cane, Indigo, Cotton-tree, and Tobacco cover the cultivated plains. In Missouri, Texas, Arkansas, and Mexico, the great colony of the Cactuses arise into lofty stems. In this region *Cactus opuntia*, *Cereus*, *Echinocactus*, and *Melocactus* raise their oddly branching stems and clustering flowers. The most remarkable of all doubtless being *Cereus giganteus*. It inhabits the wildest and most inaccessible regions, requiring little or no soil to attain a prodigious development. It has at first the appearance of an enormous tomahawk. Thence rises a column, three yards high, which branches off and assumes the shape of an immense candelabrum, the height of which may be twelve or thirteen yards. Plate XXI. p. 494, is a representation of several Cactuses belonging to this region, from an original drawing by M. Bende, a French traveller in this country. Mexico, according to the reports of botanists, may be divided into three regions by its several latitudes. The first extends from the valleys as far as the Oak forests; this is the region of Palms, Cotton, Indigo, Sugar-cane, Coffee plant, and other fruits of the tropical zone. The second, situated at an elevation of six thousand feet above the sea, is the temperate region. It stretches from the Oak forests to the forests of Coniferæ. At this height the temperature is still sufficient to ripen some tropical fruits. The third, or cold region, occupies a space comprehended between the conifers and eternal snow. In many places it possesses a climate under which Pear, Apple, and Cherry trees, and the Potato, can still expand and ripen their fruits and tubers. In ascending from the foot of Orizaba, Mimosas, Acacias, Cotton trees, successively appear and disappear, to be replaced by the Convolvulus, Trumpet flowers, Oaks, Palms, Bananas, Myrtles, Laurels, Terebinthaceæ, Ferns, Magnolias, Arborescent-Ferns, Composites, Plane-trees, Storax, Apples, Pears, Cherries, Apricots, Pomegranates, Lemon and Orange trees, Orchids, Fuschias, and Cactuses.

In the plains of Venezuela, known under the name of Llanos, over which we propose to conduct the reader, we shall find in Von Alexander Humboldt a faithful and eloquent guide to the vegetation. "We entered," he says, "into the basin of the Llanos, in the Mesa of Pesa, in 92° of latitude. The sun was nearly at its zenith; the earth, wherever it appeared, was sterile and destitute of vegetation; the temperature was at 48° to 50° Cent.; not a breath

of wind was felt, as we rode upon our mules. Nevertheless, in the midst of this apparent calm, whirlwinds of dust rose unceasingly, chased by little currents of air, which only skimmed the surface of the soil and raised the dust, giving birth to a difference of temperature between naked sandy places and those covered with vegetation, which rendered the former suffocating." Through this atmosphere of quartz grains, dry fog, and banks of vapour, sometimes waving and sinuous, sometimes even-shaped, continues the learned traveller, "I saw naked trunks of palm-trees, destitute even of their crowning tuft of verdure. The trunks appear in the distance like the masts of ships on the horizon. There is something imposing, but sad and melancholy, in the uniform appearance of these steppes. Everything appears immovable; the shadow of a little cloud, which sometimes traverses the zenith, announcing the approach of the rainy season, is scarcely projected upon the savannah. The steppes are principally covered with graminaceous plants, such as *Killengia*, *Cenchrus*, and *Paspalum*. With these we find a few plants of the dicotyledonous class, such as the *Turnera*; some *Malvaceæ*, and, what is very remarkable, the little *Mimosa pudia*, with leaves quite sensitive to the touch, which the Spaniards call *Dormuderas*. The same race of cows which in Spain fatten upon sainfoin and clover, here find excellent nourishment in the herbaceous Sensitive plant. In the east, in the Llanos of Cairo and white Barcelona, the *Cypura* and *Craniolaria*, with their beautiful flowers, six to eight inches long, rise isolated among the graminaceous plants. The pasturage is fertile, not only near rivers subject to inundations, but also where the trunks of the palm-trees are most crowded, which is attributable to the shelter and protection which they give from the sun's rays—which is the more remarkable, since the Palm of the Llanos (*Corypha tectorum*) has only very few corrugated and palmate leaves, like those of the *Chamærops*, the lower of which are always parched and dried up. Beside the isolated trunks of Palms we also find, here and there, in the Llanos, groups of Palms in which the *Corypha* mingles with a tree of the family of *Proteaceæ*—a new species of *Rhopala*, with hard and resonant leaves. In the Llanos of Caracas, the *Corypha* extends from the Mesade Paja to Guayaval. More to the north and northwest, it is replaced by another species of the same genus, with

leaves equally palmate, but much larger. To the south of Guayaval, other Palms predominate, chiefly the pinnate-leaved *Piritu* and the Mauritia Palm, the Sago-tree of America, which supplies farinaceous food, good wine, thread to weave into hammocks and clothes, and wands to make baskets; its fruit, in shape, resembling pine-cones, being covered with scales, like those of *Calamus Rotang*, with something of an apple taste. The Guaraous, whose very existence, so to speak, depends on the Murichi Palm (*Mauritia flexuosa*), obtain an acid and very refreshing fermented liquor from it. This Palm has large, shiny, corrugated, and fan-like leaves; maintaining a most beautiful verdure in times of the greatest drought. The sight of it alone in the Llanos produces an agreeable and refreshing sensation; and the Murichi, laden with its scaly fruit, contrasts singularly with the sad aspect of the Palm of Cobija, the leaves of which are always grey, and covered with dust."

As we ascend from the low country of central America towards the high ridges of the Cordilleras, whirlwinds of snow and hail succeed, each day, and for several hours, to the hot rays of the sun. If we ascend the Andes, between 20° south latitude and 5° north, at a height of from five thousand to nine thousand feet above the sea level, we shall find extra-tropical forms of vegetation become more abundant. The Graminaceæ, some Amentaceæ—such as the Oaks, Willows, the Labiateæ, Ericineæ, numerous Compositeæ, Caprifoliaceæ, Umbelliferæ, Rosaceæ, Cruciferæ, Ranunculaceæ. Tropical plants, on the contrary, disappear, or become very rare; but still, isolated species of Palms, Pepper plants, Cactuses, Passion flowers, and Melastoma, are found at considerable heights. Among the most abundant ligneous species is the *Ceroxylon andicola*, the highest of all the Palms, which reachs the height of one hundred and eighty feet and upwards, and produces a wax which exudes from its leaves, and from the base of their petioles. Humboldt's Willow and Oak, several species of Cinchona and other Quinquinas, which here reign supreme; a few Hollies and Andromedas. Vegetables cultivated between the tropics, in Mexico, and as far south as the river Amazon, disappear almost entirely here; but Maize and Coffee, the cereals and European fruits, are cultivated in these regions; Potatoes; *Chenopodium chinoa*, the seeds of which, when boiled, serve as food for the inhabitants of the mountains.

If we ascend to the height of nine thousand feet above the sea on the Andes, and in the same latitude, tropical forms of vegetation almost entirely disappear. Those, on the contrary, which characterise temperate climates, and even of the polar regions, become abundant. Large trees are no longer seen. Alder bushes, Bilberries, Currants, Escallonia, with bitter and tonic leaves, of which this is the home; Hollies and Drymarias are bushes belonging to these regions, as well as the curious Calceolarias, with shoe-shaped corolla, the seeds of which have supplied horticulture with an infinite number of varieties. Amongst the characteristic families we also find Umbelliferæ, Caryophyllaceæ, Cruciferæ, Cyperaceæ, Mosses, and Lichens. Returning to more circumscribed vegetable districts, the climate of Caracas has often been called one of perpetual spring. A more delicious temperature cannot be conceived. During the day it ranges between 16° and 20° Cent., and in the night between 16° and 18°, with vegetative powers at once favourable to the growth of the Banana, the Orange, the Coffee shrub, the Apple, Apricot, and Wheat.

We must not quit these regions without mentioning two beneficent trees—the *Theobroma cacao* and the Cow-tree. The roasted and crushed seeds of *Theobroma cacao*, with the addition of sugar, make chocolate. Humboldt gives the following account of the Cow-tree, which has much of the bearing of *Chrysophyllum ainito.* "The fruit," Humboldt tells us, "is rather fleshy, consisting of one, sometimes two nuts. When incisions are made in the trunk an abundance of thick glutinous milk flows, which is without any acidity. This substance exhales a very agreeable balsam-like odour. It was presented to us in the fruit of the Calabash-tree. We drank considerable quantities of it in the evening before going to bed, and again early in the morning, without experiencing any injurious effects. Negroes and free people who work in the plantations drink of it, and soak their bread, maize, or tapioca in it. The master of the farm assured us that the slaves fattened visibly during the season when the *Palo de Vacca* furnishes them with most milk. Upon the arid flank of a rock," adds Von Humboldt, "there grows a tree whose leaves are dry and coriaceous, its great ligneous roots almost piercing the stone. During many months of the year not a shower waters its foliage, the

branches appear dry and dead; but when the trunk is pierced a sweet and nourishing milk follows the incision."

Shall we now describe the wild beauties of the impenetrable forests of Guyana? take our walk in these immense savannahs, animated by Graminaceæ, by clusters of Myrtaceæ, magnificent Orchids and Melastoma, while elegant Palm-trees here and there arrange themselves in picturesque groups? or shall we rather navigate the tranquil waves of the quiet Guyana, upon whose waters the splendid Victoria Regia spreads her broad leaves, while its magnificent flowers proclaim her queen of the Nymphaceæ?

In order to penetrate to the heart of the vegetation of Brazil, the region of Palms and Melastoma, this land of promise to naturalists, we shall again take as our guide Messieurs Martins and Auguste de St. Hilaire, who have written with much exactness on the vegetable wonders displayed in the Brazilian forests. Their aspect varies according to the nature of the soil, and the distribution of water traversing them. If these forests are not the seat of a constant supply of moisture, or if the moisture is only renewed by periodical rains, the drought stops the vegetation, and it becomes intermittent, as in European climates. This is the case in the Catingas. The vegetation of the untrodden forests, on the contrary, of which Auguste de St. Hilaire gives an eloquent picture, is the reverse of this; excited by the ceaseless action of the two agents, humidity and heat, the vegetation of the virgin forests remains in a state of continual activity. The winter is only distinguished from the summer by a shade of colour in the verdure of the foliage; and if some of the trees lose their leaves, it is to assume immediately a new appearance. Now let us listen to the French botanist. Auguste de St. Hilaire says, "When an European arrives in America, and sees from a distance the untrodden forests for the first time, he is no longer astonished at all the singular forms which he admired in European hothouses; here they are mingled in masses and lost. But he is astonished to find in the outline of the forests so little difference between those of his own country and those of the New World. If anything strikes him, it is only the grandeur of the proportions and the deep green colour of the leaves, which, under the most

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brilliant sky imaginable, impart a grave and severe aspect to the landscape.

"In order to appreciate all the beauties of a tropical forest, we must plunge into retreats as old as the world. Nothing there reminds us of the fatiguing monotony of our Oak and Fir forests; each tree has a bearing peculiar to itself. Each has its own foliage, and often its own peculiar shade of verdure. Gigantic specimens of vegetation, each belonging to different, sometimes to remote families, mingle their branches and blend their foliage. Five-leaved Bignoniæ grow beside Cæsalpinias, and the golden leaves of the Cassia spread themselves in falling upon arborescent Ferns. Myrtles, and Eugenias, with their thousand times divided branches, are finely contrasted with the elegant simplicity of the Palms, and Cecropia spreads its broad leaves and branches, which resemble immense candelabra, among the delicate folioles of the Mimosæ. There are trees with perfectly smooth bark, others defended by prickly spines; and the enormous trunk of a species of Wild Fig spreads itself out like oblique blades, which seem to support it like so many arched buttresses.

"The obscure flowers of our Beeches and Oaks are only perceptible to naturalists; but in the forests of South America gigantic trees often display the most brilliant colours in their corolla. Long golden clusters hang from the branches of the Cassia. The Vochysias erect their thrysus of odd-shaped yellow flowers. Yellow and sometimes purple corollas, longer than those of our Digitalis, cover in profusion the tree of the Trumpet-flowered Bignonia; and the Chorisia are decked in flowers which somewhat resemble our Lily in shape, and remind us of the Alistræmeria from the mixture of colours they present.

"Certain vegetable forms, which assume at home very humble proportions, present themselves with a floral pomp unknown in temperate climates; some Borraginaceæ become shrubs, many Euphorbials assume the proportions of majestic trees, offering an agreeable shelter under their thick umbrageous foliage."

But it is principally among the Gramineæ that the greatest difference is observable. Of these there are a great number which attain no larger dimensions than our Wild Oat (*Bromus*), forming masses of grass only distinguished from European species by their

stems being more branchy and the leaves larger. Others shoot up into lofty *stipes* of graceful appearance. At first they are upright as a lance, terminating in a point, with only one leaf, resembling a large scale, at each internode; when these fall, a short branchy crown springs from their axilla bearing the true leaves. The stems of the Bamboos are thus decorated with verticillate leaves, at regular intervals, which are naturally curved, and form elegant arbours between the trees. It is to the *Lianes* principally that tropical forests are indebted for their picturesque beauty, and these are the source of the most varied effects. The Honeysuckle and the Ivy give but a faint idea of the appearance presented by the crowd of climbing and creeping plants belonging to many different families. These are *Bignoniaceæ, Bauhinia, Cissus,* and *Hippocrateas*, and while they all require a support, they each have notwithstanding a bearing peculiar to themselves. One of those climbing parasites will encircle the trunk of the largest trees to a prodigious height; the marks left by the old leaves seeming in their lozenge-shaped design to resemble the skin of a serpent. From this parasitic stem spring large leaves of a glossy green, while its lower parts give birth to slender roots, which descend again to the earth straight as a plum-line. The tree which bears the Spanish name of *Cipo-Matador*, the Murderous Liane, has a trunk as straight as our poplar, but so slight that it cannot support itself alone, but must find support on a neighbouring tree more robust than itself. It presses against its stem, aided by its aerial roots, which embrace it at intervals like so many flexible osiers, by which it secures itself and defies the most terrible hurricanes. Some Lianes resemble waving ribbons, others are twisted in large spirals, or hanging in festoons, spreading between the trees, and darting from one to another, twining round them and forming into masses of stem, leaves, and flowers, where the observer often finds it difficult to render to each vegetable what belongs to it.

Thousands of different species of shrubs, Melastomaceæ, Borraginaceæ, Pipers, and Acanthaceæ, springing up round the roots of large trees, fill up the intervals left between them. Tillandsias and Orchids, with flowers of strange and whimsical shape, make their appearance, and these often serve as supports to other parasites. Numerous brooks generally run through these forests,

communicating their own freshness to the forest vegetation, presenting to the tired traveller a delicious and limpid water, while the banks of the stream are carpeted with mosses, Lycopodes, and Ferns, from the midst of which spring Begonias, with delicate and succulent stems, unequal leaves, and flesh-coloured flowers. Plate XXIII. is a reproduction of a celebrated engraving published about the year 1825. It represents the untrodden depths of a Brazilian forest, from a picture by the Count de Forbin, Director of the Royal Museum. If we glance at the vegetation of the countries of the great American continent situated above the tropic of Capricorn, which constitute Chili, La Plata, and Patagonia, we shall find two Palms in Chili,—these are the *Jubæa Spectabilis*, and the *Ceroxylon australis*, a magnificent tree; the *Araucaria imbricata*, which rises to the height of a hundred and fifty feet; its verticillate branches lying almost horizontally, and covered with spiny leaves. This tree here forms immense forests. A few Gramineæ, Heaths, Labiatæ, Umbellifers, Fuchsias, Loasas, Myrtles, and Laurel-bushes, but particularly ligneous composites, form the chief part of the vegetation.

The forests of Paraguay, still little known, situated along the coast of the Atlantic, consist of ligneous *Compositæ* and *Ilex Paraguensis*, usually called Paraguayan Tea, of which Paraguay annually exports nearly five hundred million pounds.

In the Argentine Republic, Auguste de Saint Hilaire found about five hundred species of plants, amongst which only fifteen belonged to families which are not European.

When we reach the south coast of Patagonia and the Falkland Islands, a few brown and coriaceous Gramineæ and Cyperaceæ, such as *Dactylis cæspitosa*, *Carex trifida*, *Bolax glebaria*, Nine-leaved Oxalis, *Cardamine glacialis*, a Veronica, a Calceolaria, an Aster, *Opuntia Darwinii*, *Lomaria Magellanica* among the arborescent Ferns, a few Brambles, thickets of Bilberries and Arbutus, include nearly the whole of the vegetation of these desert lands, where Mosses, Hepaticas, and Lichens reign supreme. We now reach the southern part of South America. We approach the South Pole; consequently vegetation almost entirely ceases: we find upon this frozen soil the general characteristics of Polar vegetation. In the stormy region of Terra del Fuego thick

forests cover the mountains, where they are sheltered from the wind, to the height of fifteen hundred feet above the level of the sea. The Beech, with Birch-like leaves, predominates there; then comes the Antarctic and Forster's Beech, accompanied by Barberry and Currant bushes.

At the Hermit's Isle, the most southerly point of the American continent, there is still some arborescent vegetation. Hooker there observed eighty-four flowering plants and many Cryptogams. A Mushroom found there constitutes the principal aliment of the miserable inhabitants of these glacial regions.

Australian Vegetation.

The Australian Flora and Fauna are somewhat different from those of any other part of the world. From the state of our geological knowledge it does not appear possible that this part of the world can be considered contemporary with either of the other divisions of the globe. The study of animals and plants of Oceanca leads naturalists to the conclusion that these countries belong to a later creation than the rest of the earth: that its islands emerged from the deep at a period posterior to the continents of Europe, Asia, Africa, and America; and it seems to belong to the tertiary or secondary epochs. In fact all the Marsupial animals belong to a type of Mammiferæ inferior to those found in the fossil state in Jurassic rocks, and its vegetation presents such anomalies as might be expected in the tertiary period more than in that of our days. It presents forms more ancient than any other contemporary vegetation. More than nine-tenths of the species found between 33° and 35° south latitude, in Australia, absolutely belong to these regions. They constitute several completely-distinct families. Others form families which are scarcely represented in any other part of the globe. Those even which belong to groups more generally diffused, disguise their natural affinities under forms so isolated and unlike their congeners, that they have been called the masques of the vegetable world. The different species of two genera, namely, the *Eucalyptus* among the Myrtaceæ, and the *Acacia* among the Leguminoseæ, form perhaps, from their number and dimension, one half of the vegetation which covers the country (Fig. 109). Their leaves are reduced to phyllodium. Neither

these phyllodes nor the limb of the real leaves are placed horizontally, like those of Europe and other parts of the world, but, as represented in the engraving, they are perpendicular to the surface of the soil, so that the light shining between these vertical blades is not arrested, as is the case with our trees and bushes. The consequence is that the leaves are placed transversely one above the other; hence they are only subjected to one series of reflections, producing results not familiar to us.

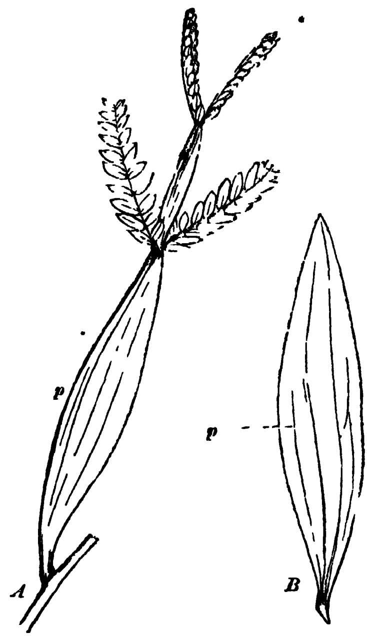

Fig. 447.—Acacia Pentadenia.
p, the petiole, forming a flat, leaf like member, or phyllodium, A, with leaflets, B, the phyllodium, without any leaflets.

The effect produced by masses of Australian verdure is thus entirely different from that to which we are accustomed in Europe. The aspects of these forests particularly struck the first travellers who visited them, from the singular sensation communicated to the eye by this mode of distributing light and shade.

The Eucalyptus, which occupies such a large place in Australian vegetation, may be said to be the sacred tree with the natives; it shadows the tombs of the savage inhabitants of these countries. Sir Thomas Mitchell, the traveller to whom we owe the first scientific description of Australia, has given a remarkable picture of these "groves of death," which are daily becoming more and more rare, and will disappear under the influence of European colonisation. He relates that these groves mark the centre of the patrimonial land of each great Australian tribe. Little *tumuli* of grass, and sandy footpaths, surround the clumps of these funereal squares, over which spreads the shadow of the Eucalyptus and Xanthorrea. In addition to the magnificent Eucalyptus and simple-leaved Mimosa,

which predominate in the forests and give quite a special character to Australian vegetation, if we name the Xanthorrea, the Casuarina, the *Araucaria excelsa,* a few elegant Epacrideæ, a great number of pretty Leguminoseæ and Orchidaceæ, we shall give a general idea of the vegetable mantle which covers and decorates, in a manner so original, the whole continent, if we may so call it, of Australia. The Xanthorrea has a thick stem; long, narrow, linear leaves, curved and spreading at the summit, from the centre of which rises an elongated stipe, terminated by a spike of robust flowers, which impress their peculiar character on all places where it abounds. The Casuarina has long, pendent, and drooping boughs, most delicately articulated. *Araucaria excelsa,* whose column-like trunk and verticillated branches rise to the height of ninety or a hundred feet; the elegant Epacrideæ with flowers so varied; a vast number of pretty Leguminosæ, which now add to the riches of our hothouses; more than a hundred and twenty Orchidaceæ—nearly all belong exclusively to the special vegetation of Australia.

The large islands of New Zealand almost correspond in latitude to the zone which we have been examining. These islands are the nearest land (considering Van Diemen's Land as part of Australia) and are interesting as being the direct antipodes of Western Europe, and because they repeat as it were our Mediterranean region on the other side of the globe. While resembling it in climate, however, the native vegetation has its own characteristics. It has some features in common with Australia and the tropics, as will appear from the account given of them by Messrs. Richard and Lesson, whose account we chiefly follow.

In the large island of Tha-na-Mawi there are immense forests of Lianes and interlacing shrubs, which render them impenetrable. In these forests there exist, no doubt, trees of gigantic dimensions, for the canoes of the natives are sometimes as much as sixty feet long, and from three to four broad, all hollowed out of one trunk. At from two to four miles from the coast Messrs. Richard and Lesson saw large spaces, very low and probably marshy, covered with great masses of green trees, of which the *Dacrydium cupressinum* and *Podocarpus dacrydioides,* and some others, form the principal species. The vegetation of the harbour where the *Astrolabe* lay was very beautiful, although the number of cryptogamous

plants almost equalled that of the Phanerogames. The European is surprised to meet there many vegetables from home, or closely allied to them, such as Senecios, Veronicas, Rushes, the Acrid Ranunculus, &c.; and, on the other hand, several unknown vegetables, particularly those of New Zealand, grow abundantly in these localities, such, amongst others, as the *Phormium tenax*, called by Europeans New Zealand Flax, because its fibres furnish a very strong thread, very much used in the manufacture of certain fabrics.

Ferns form almost a seventh of the whole vegetation of this country. Among the monocotyledons are the Gramineæ and Cyperaceæ. Among the dicotyledons the Umbelliferæ, Cruciferæ, and Œnotheræ. New Zealand only furnishes a small number of alimentary plants. The aboriginal inhabitants of this archipelago, for the most part icthyophagons, were long reduced to the feculent root of a Fern, the *Pteris esculenta*, for food, when they could not obtain fish. None of their trees produce large fruit. The Taro or *Caladium esculentum* and the Sweet Potato (*Convolvulus batatus*) also serve as nourishment to the inhabitants of these countries. It is to be remarked that European vegetables, introduced into New Zealand by sailors, are propagated there with such facility that the aspect of the ground, as well as conditions of life, are greatly modified. Amongst the vegetables proper to the archipelago in question we may note the *Corypha australis* amongst the Palms, arborescent Dracænas, forests of Coniferæ, with large leaves, the *Dammara*, and *Metrosideros* amongst the Myrtaceæ.

Mountain Vegetation.

We have briefly traversed the principal botanical regions of the globe; and in the course of our survey, we have seen that vegetation changes with the latitude: that is to say, according to the distance of the equator. As we advance from the equator towards the poles we meet in succession with the equatorial, tropical, temperate, and polar zones—vegetation gradually losing its power, a fact which is proved most satisfactorily by the decreasing number of species and by their dwarfed appearance, until vegetation altogether ceases in the region where snow reigns eternal. When heat disappears organic life is extinguished, and vege-

table organisation is subject to the same laws, and experiences loss of power and vigour proportioned to the decrease of heat.

But a natural reflection presents itself immediately, as a corollary upon these remarks.

When we ascend a mountain, or, in fact, when we ascend by any means whatever,—in a balloon, for instance, as Mr. Glaisher's experiments seem to show,—the temperature decreases by something like one degree for every hundred yards above the surface. It follows from these premises that every stage in the ascent of a mountain should exhibit different forms of vegetation, each forming a zone or botanic region, similar to those we have passed in tracing their geographical latitudes. And this is so in fact, as we shall find in the following remarks, which we borrow from the writings of Adrien de Jussieu on the vegetation of the Alps, Professor Ch. Martin, on Mount Ventoux in Provence, and Dr. Hooker, on the Himalayas :—

"Let us imagine a spectator at the foot of the Alps," says M. de Jussieu, "opposite to one of those grand rocky masses crowned with eternal snow. As his eye ranges along the sides of the mountain, he observes that the vegetation which immediately surrounds him, and which is that which characterises central and northern France, disappears at a certain height, giving place to another, which in turn disappears at a higher range. Beyond a certain distance the eye can only seize the masses indicated by large trees, the humbler plants being concealed behind them, so that they look like a series of bands superposed one over the other on the slopes of the mountain. At first these belts are composed of deciduous-leaved plants, which drop early, and are readily distinguishable by their more tender verdure, than conifers of deeper green, which in the mass appear nearly black. Another belt succeeds of an undecided green, interrupted here and there by clumps of another colour, which goes straggling up to the sinuous line where the snow commences. This is owing to the circumstance that the trees whose branches are too closely intermingled have died out, making room for shrubs or herbaceous plants, more dwarfed in their growth, and more on a level with the soil.

"If the spectator approaches the mountain and scales it, he will

find other plants, very different from the masses he looked at in the distance, which we call Alpine plants—such as the Aconites, Astrantia, certain species of Artemisias, of Groundsel, Prenanthes, Achilleas, Saxifrages, and Potentillas. After having skirted the Walnut-trees, and traversed the woods formed of Chesnut-trees, these will be observed to cease, and forests of Oaks, Beeches, and Birches take their place. Of these, the Oaks disappear first, at the height of about two thousand five hundred feet above the level of the sea, the Beeches about three thousand. Beyond this the trees consist entirely of evergreen trees, as Firs, Larches, and the common Pine, which stop also at certain successive stages, about four thousand five hundred feet. The Birch ascends a little higher, but disappears also at about six thousand feet of elevation. A conifer (*Pinus cembro*) continues for another hundred yards. Beyond this limit the trees become dwarfed in size; for example, a species of Alder (*Alnus viridis*) becomes a low shrub. Near to this the botanist will find himself surrounded by shrubs very characteristic of the Alps, sometimes called the Alpine Rose, namely, the Rhododendron, which ceases in its turn only a little higher, giving place to plants much more lowly, which scarcely rise above the soil. These are specially known as Alpine plants. They belong to families which he observed at his point of departure. A few Crucifers, Caryophyllum, Rosaceæ, Liguminoseæ, Compositeæ, Cypriaceæ, Gramineæ, but of different species. These also are numerous, and with them representatives of other families which rarely show themselves in the plains, such as Saxifrages, Gentians. Annuals cease almost entirely, as might be foreseen, since an unfavourable season, in which the ripening of their seeds was checked, would be sufficient to destroy their race."

The roots of perennial or woody plants bury themselves under the soil, where a higher temperature is preserved. They submit themselves to the influence of the atmosphere and develop themselves when it is milder and sufficiently warm. But this can only be done during a short season, and on some places only once in many years. It follows that the stems are short and scarcely rise out of the soil, while those that are frutescent usually hug the ground, sometimes creeping, sometimes raising short, hardy, intertwining stems, forming thick stunted bushes, as would result

in ordinary cases from pruning shrubs very near the ground. The general appearance proper to the plant is thus effaced in some respects, and replaced by the physiognomy belonging to Alpine vegetation. These plants are generally of the arborescent kind, like the Willows, whose roots creep along the ground. The more elevated they are, the more scattered and impoverished is the vegetation, until, at the foot of the rocks, it only appears in the form of lichens, whose crust differs little from the monotonous tint of their own surface. When the limit of eternal snow is reached, organised life can no longer exist.

Mount Ventoux, in Provence, presents us with an interesting application of the same facts. This mountain rises abruptly from a plain, the temperature of which may be compared with that of Sienna, Brescia, or Venice, while the summit of the mountain approaches the climate of Sweden, on the borders of Lapland. To ascend its sides and reach the summit, is as if we had actually traversed nineteen degrees of latitude, or from 44° to 63°. Professor Charles Martins has published an interesting account of the vegetation of this mountain. "Mount Ventoux," says the learned Professor of Montpellier, "presents a succession of well-defined botanical regions, each characterised by the presence of plants which are wanting on the others. These regions are six in number upon the southern slopes, and five on its northern side.

"Ascending the southern slope, its base, in respect to its vegetation, is like that of the valley of the Rhone. All the plants of the plains are found in the region at the foot of the mountain, and they are well characterised by two trees—the Aleppo Pine and the Olive. Both belong to the basin of the Mediterranean, round which they form a girdle, only interrupted by the delta of the Nile. The Aleppo Pine is found upon all the hills which lie at the southern foot of Mount Ventoux, but ceases at the height of fourteen hundred feet above the level of the sea. The Olive ascends a little higher, but ceases also at sixteen hundred. Under these trees we meet with all the species which characterise the vegetation of Provence. The Kermes Oak, the Rosemary, the Spanish Broom, and *Dorycinium suffraticasm*. A narrow zone scarcely exceeding a hundred and eighty feet succeeds to this, which is characterised by the evergreen oak. Among the under-shrubs we find the

European Leadwort, the Juniper, the great *Eurphorbia characias*, the *Psoralea*, of bituminous odour, &c.

"A region altogether destitute of arborescent vegetation follows. The soil is here naked, stony, and generally uncultivated; nevertheless, here and there fields of chick peas, oats, and barley appear, the last of which disappears at three thousand five hundred feet above the Mediterranean; but a shrub—the Box Tree—two undershrubs—Thyme and Lavender—another herbaceous Labiatæ (*Nepeta graveolens*), and the Swallow-wort (*Vincetoxicum officinalis*), predominate as to size and number. It is at this point that the first indications of an arborescent vegetation appear, but it is necessary to ascend to three thousand eight hundred feet before reaching the new vegetation. It is composed of Beeches; at first sparse and undersized, they get larger three hundred feet higher, especially in the deep ravines and valleys, where they are sheltered from the wind. This region extends as high as five thousand five hundred feet. At this height the depressions are slight; valleys and ravines almost cease, and the trees are exposed to the depressing action of the winds. The plants which clothe the soil are now humble bushes, with short, hard, and crowded branches. One of these bushes, like a large ball or mattrass extended on the earth, is often as old as the great Beeches which elevate their proud heads to the heavens in the valleys below. Numerous species occupy the region of Beeches, many of them belonging to the sub-alpine zone of the mountains of central Europe, never descending into the plains, unless transplanted. Such are the Buckthorn, the Gooseberry, the Wallflower, the Mountain Sorrel, and the mountain *Anthylis*.

"At the height of five thousand six hundred feet the cold is intense, the summer brief, and the wind so violent that the Beech can no longer exist. As upon Mount Ventoux, so it is on the Alps and Pyrenees,—on all, a tree of the family of Conifers is the last representative of arborescent vegetation. It is a humble species of pine, called the Mountain Pine (*Pinus uncinata*), because the scales of its cone are curved into a sort of claw. These Pines are found many feet in height in sheltered places, but become mere bushy shrubs when exposed to the sweep of the winds. They ascend as high as six thousand feet, the extreme limit of arborescent vegetation.

The herbaceous plants of this region are the same as in the region of Beeches, which nearly all attain the limit of the Pines. In addition to the common Juniper, resting on the soil, as it always does, on high mountains, where the weight of the snow crushes it all the winter; we find the mountain Germander (*Veronica montana*) and the Tufted Saxifrage (*S. cæspitosa*), which is found on the loftiest ridges of the Alps.

"Its flora thus teaches us, in the absence of the barometer, that we have reached the Alpine region of Mount Ventoux, and that the region of aborescent vegetation has disappeared. But here the botanist will be delighted to find the flora of Lapland or Iceland, and of Spitzbergen also. In the Alps this region extends to the line of perpetual snow, the home of eternal winter. But as Mount Ventoux is only six thousand three or four hundred feet high, the summit only extends to the lower zone of the Alpine regions in the Alps and Pyrenees. At this point all trees have disappeared, but a crowd of small plants expand their corollas on the stony surface. Among them the orange-flowering Poppy, the Violet of Mount Cenis, the blue-flowered *Astragalus*, and quite at the summit, the Meadow Grass of the Alps, Gerard's Euphorbia and the Common Nettle, which is generally found wherever man fixes his dwelling. A chapel has been built on the summit of the mountain since the ascent of Petrarch. But it is not on the south terminal summit, that the botanist will seek for the Alpine plants characteristic of the loftier regions. It is on the northern declivities, on the rocks exposed to the glacial north winds, nearly deprived of the sun during long months, and covered with snow from June. These I have surveyed as I would survey an old friend. The Purple Saxifrage (*S. oppositifolia*) was the first plant I recognised; I had gathered it on the summit of the Reculet, the loftiest ridge of the Jura, and upon all the summits of the Alps which reached or passed the limits of perpetual snow. When I put foot for the first time on the icy shores of Spitzbergen, the Purple Saxifrage was among the first plants which attracted my attention; for here is found, on the shore of the sea, the cold summers and the melting snow of the summits which crown the Alps and the Pyrenees. Upon Mount Ventoux other Saxifrages, equally Alpine, surround it. The blue bell-shaped flowers of *Campanula Allioni* raised its

head from a heap of stones and dwarf plants, which covered all these heights; the round-headed Phyteuma, the hairy *Andrasace* the *Ononis* of Mount Cenis, and three species of *Arenaria*, clung to the rocks or peeped through the stones."

For the sake of comparison let us leave Provence and Europe, and glance at the ranges, in the heart of Asia, of the lofty Himalayas, or "abode of snow," as the word means, in the figurative language of the Asiatics. Dr. Hooker passed the rainy season of 1848 in the sanitary establishment of Dorjilling, the farthest English possession, in Sikkim, seven thousand two hundred feet above the sea, having in sight the loftiest peaks of the range. Twelve of these are more than twenty-four thousand feet high, and one of them, Kinchinjunga, attains the height of twenty-nine thousand three hundred feet. Mount Chumulari, another giant of the Himalayas of Thibet, was visible from a neighbouring peak, the Sinchul, during the ascent of which the author made his first acquaintance with some of the beautiful Rhododendrons with which he afterwards enriched the gardens of Europe. "In the month of May," says the Doctor, "when the Magnolias and Rhododendrons are in flower, the magnificent vegetation of the Sinchul yields nothing in certain respects to that of the tropics, the beauty of the effect being, however, much diminished by the constant gloom of the season. The white-flowered Magnolia (*M. excelsa*) is one of the trees which predominate at the elevation of seven thousand to eight thousand feet, and in 1848 it had flowered so abundantly that it seemed as if the broad sides of the Sinchul and other mountains at the same elevation were covered with snow. The purplish-flowered species (*M. Campbellii*) does not appear under the elevation of eight thousand feet. It is a large but unsightly tree, with dark—almost black—bark, and few branches, destitute of leaves in winter and while in blossom, but throwing out at the extremity of the branches great bell-shaped flowers of a purplish rose colour, the fleshy petals of which cover all the surrounding soil.

"Upon its branches and upon the Oaks and Laurels, the *Rhododendron Dalhousia*, a slender creeping shrub, grows as an epiphyte, bearing at the extremity of its branches from three to six white bell-shaped flowers, citronous in odour and with leaves five to six inches in length. The scarlet-flowered Rhododendron is rare

in these woods, but is much surpassed by *R. argentum*, which here becomes a tree forty feet high, with leaves twelve or thirteen inches in length, of a deep green above and silvery green on the lower surface, and with flowers, large as those of *R. Dalhousia*. Oaks, Laurels, Maples, Birches, Hydrangeas, a species of Fig which grows on the summit of the mountain, and three Chinese and Japan genera constitute the chief woodland vegetation of this part of the Sinchul.

"Beyond this region, that is to say above Dorjelling, the zones of vegetation are well characterised between six thousand feet and seven thousand one hundred feet, first by Oaks, Chestnuts, and Magnolias, which equally characterise the vegetation up to ten thousand feet; secondly, immediately above six thousand feet, a tree-fern appears (*Alsophila gigantea*); thirdly, a species of Palm, of the genus *Calamus*, and a *Plectocomia;* this last shoots up the branches of the loftiest trees, extending itself over the forest to the distance sometimes of a hundred and twenty feet from its stem; finally, a last characteristic trait of the region is the Wild Banana tree, which attains nearly the same height as the preceding species."

With some difficulty Dr. Hooker obtained permission of the native authorities to go beyond Dorjelling, and, in particular, to visit the higher passes of the Himalaya in Thibet, and especially the principal mass of the Kinchinjunga. Following his steps in this ascent he found at eight thousand one hundred feet the first conifers; all of them at first *Abies Brunonia*, a fine species, which assumes the form of an obtuse pyramid, with spreading branches like the Cedar; it is unknown in the exterior chain, and occupies in the interior a zone less elevated by a thousand feet than the Silver Firs (*Abies Webbiana*). We meet also at this level with a great number of sub-Alpine plants belonging to *Leycesteria*, *Thalictrum*, *Rosa*, *Gnaphalium*, *Alnus*, *Betula*, *Ilex*, *Berberis*, *Rubus*, and some Ferns, Anemones, Strawberries, Alpine Bamboos, and Oaks.

On the higher level our traveller saw Junipers mingling with Silver Firs, which were even superseded by evergreen Rhododendrons, spreading along the slopes in immense profusion, Spiræas, dwarf Junipers, and small Birch-trees, Willows, Honeysuckles, Barberries, and a species of Service-tree. At twelve thousand

two hundred feet the vegetation was almost limited to numerous species of Rhododendrons, which formed a continuous zone of eleven hundred feet broad on the steep slopes of the mountain. A little *Andromeda* made itself quite remarkable there; and by the roadside the botanist saw two plants which reminded him of his far distant home—the Meadow Grass (*Poa annua*) and the Shepherd's Purse (*Capsella*). At thirteen thousand two hundred feet the soil becomes hard and frozen, and at twenty-two thousand feet perpetual snow covers the mountain side.

The traveller finally attained the summit of the pass at twenty-four thousand three hundred feet above the level of the sea, where he still found many species of *Compositeæ*, *Gramineæ*, and an *Arenaria*, with great masses of the curious *Saussurea gossypina*, covered with a white down, which felt soft to the touch, and about ten inches high. The species of covering given to this plant is almost exceptional among the plants of the Himalayas; the Alpine species which are scattered about, such as the Arenarias, Primroses, Saxifrages, Ranunculus, Gentians, Grasses, and Cyperads, having their foliage perfectly naked.

The following year Dr. Hooker in one of his ascents towards Thibet, collected upwards of two hundred species upon one of the crests of the Himalayas, among which he found ten *Crucifera*, twenty *Composites*, ten *Ranunculaceæ*, nine *Alcinaceæ*, ten *Astragals*, eight *Potentillas*, twelve *Gramineæ*, fifteen *Pedicularia*, and seven *Borragınaceæ*. Finally, on the 7th of September, 1849, he reached the culminating point of the Himalaya flora on Mont Donkia, at an elevation of twenty-three thousand four hundred feet, the lowest limit of perpetual snow being about twenty thousand one hundred and fifty feet. The *Arenaria rupifraga* is the only Phanerogam which he met with at this elevation; *Festuca ovina*, a *Saussurea*, and a little Fern, *Woodsia*, were, however, found very near the summit, where he observed many Lichens and some Mosses. The Lichens and Mosses are thus the last plants which disappear on the confines of life.

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THE END.

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